FIG. 1

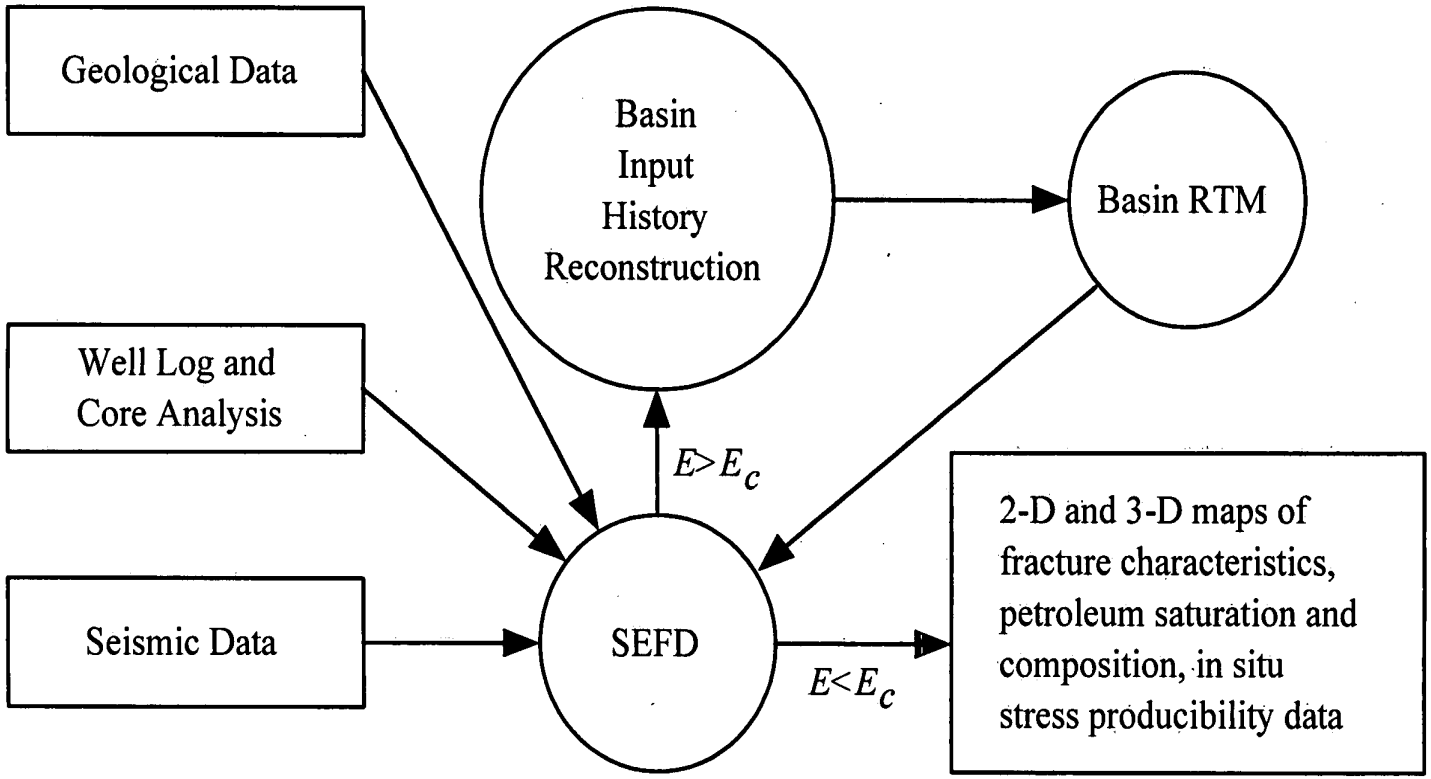

Geological Data
Well Log and Core Analysis
Seismic Data
Basin Input History Reconstruction
Basin RTM
SEFD
$E>E_c$
$E<E_c$
2-D and 3-D maps of fracture characteristics, petroleum saturation and composition, in situ stress producibility data

FIG. 2

System	Producing Lithology	Tectonics	Age (My)
Cretaceous (Austin Chalk)	Very fine-grained carbonate	Salt withdrawal, extensional	100
Devonian (New Albany Shale)	Siliciclastic, very fine-grained siliciclastics	Compression, faulting	360
Cretaceous (Mesaverde)	Fine-grained sandstones	Compression, thrusting	70
Silurian-Pennsylvanian (Anadarko Basin)	Variety	Deep subsidence and faulting	400-280
Ordovician (Permian Basin)	Vuggy and fractured carbonate (Ellenburger, etc.)	Uplift, wrenching	500

FIG. 3

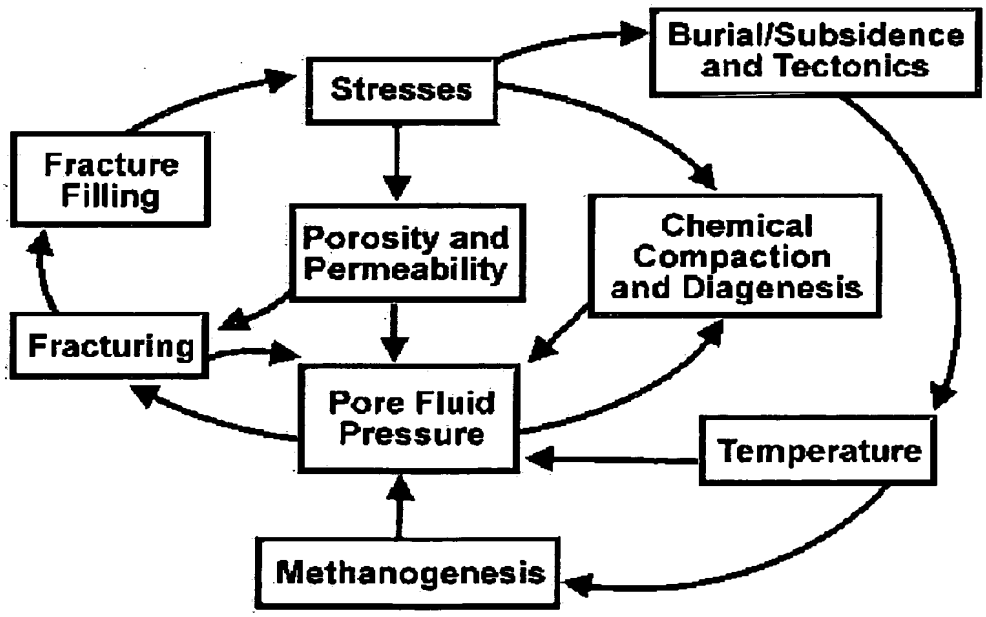

Burial/Subsidence and Tectonics
Stresses
Fracture Filling
Porosity and Permeability
Chemical Compaction and Diagenesis
Fracturing
Pore Fluid Pressure
Temperature
Methanogenesis

FIG. 4a

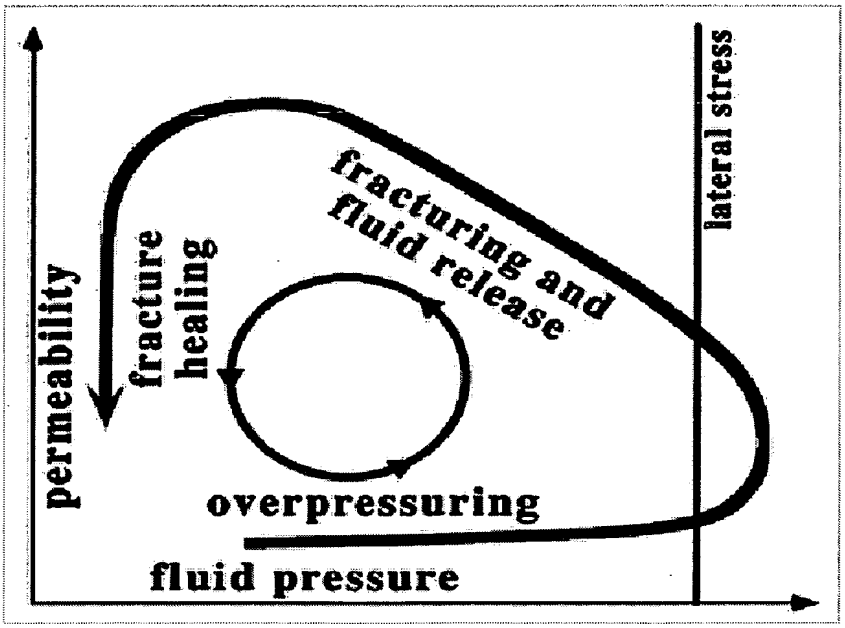

permeability
fracture healing
fracturing and fluid release
lateral stress
overpressuring
fluid pressure

FIG. 4b

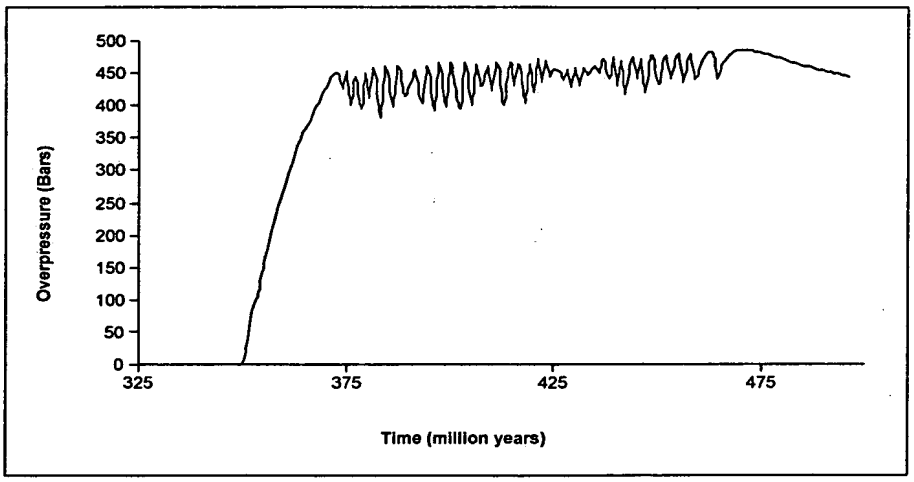

Overpressure (Bars)
500
450
400
350
300
250
200
150
100
50
0
325
375
425
475
Time (million years)

FIG. 5

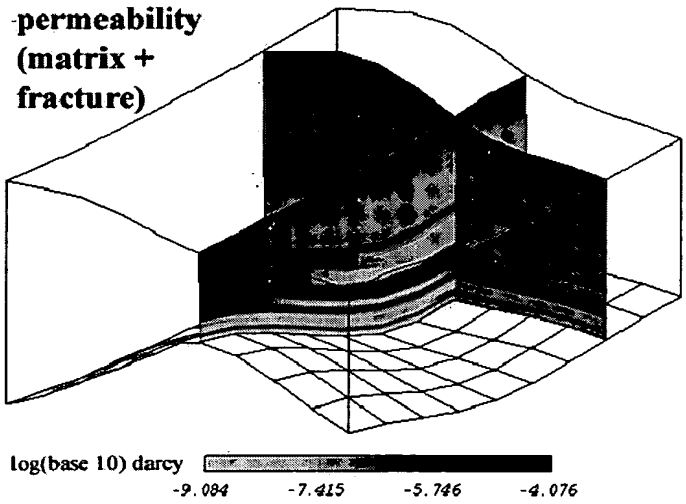

permeability
(matrix +
fracture)
log(base 10) darcy
-9.084
-7.415
-5.746
-4.076

FIG. 6a

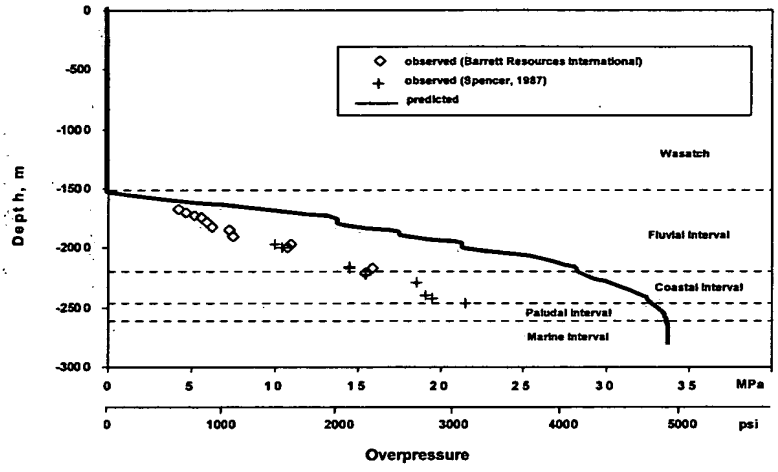

observed (Barrett Resources International)
observed (Spencer, 1987)
predicted
Wasatch
Fluvial Interval
Coastal Interval
Paludal Interval
Marine Interval
Depth, m
0
-500
-1000
-1500
-2000
-2500
-3000
0
5
10
15
20
25
30
35
MPa
0
1000
2000
3000
4000
5000
psi
Overpressure

FIG. 6b

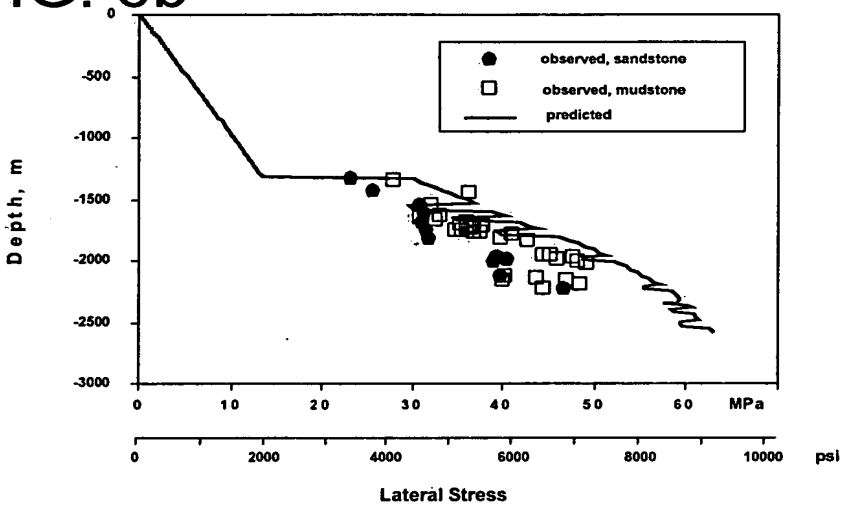

observed, sandstone
observed, mudstone
predicted
Depth, m
0
-500
-1000
-1500
-2000
-2500
-3000
0
10
20
30
40
50
60
MPa
0
2000
4000
6000
8000
10000
psi
Lateral Stress

FIG. 6c

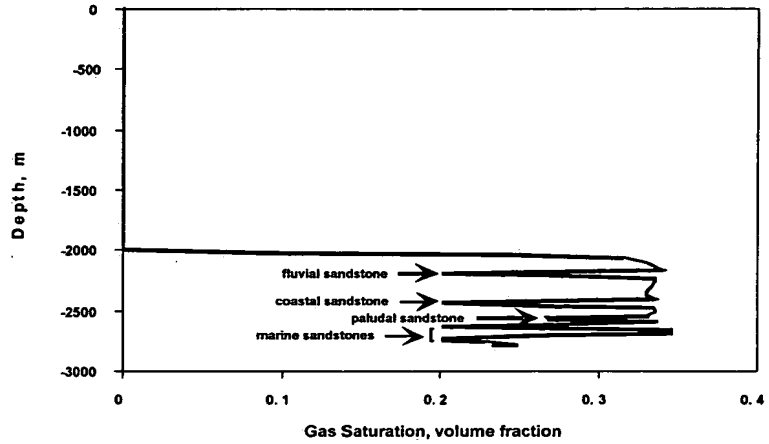

0
-500
-1000
-1500
-2000
-2500
-3000
Depth, m
fluvial sandstone
coastal sandstone
paludal sandstone
marine sandstones
0
0.1
0.2
0.3
0.4
Gas Saturation, volume fraction

FIG. 7

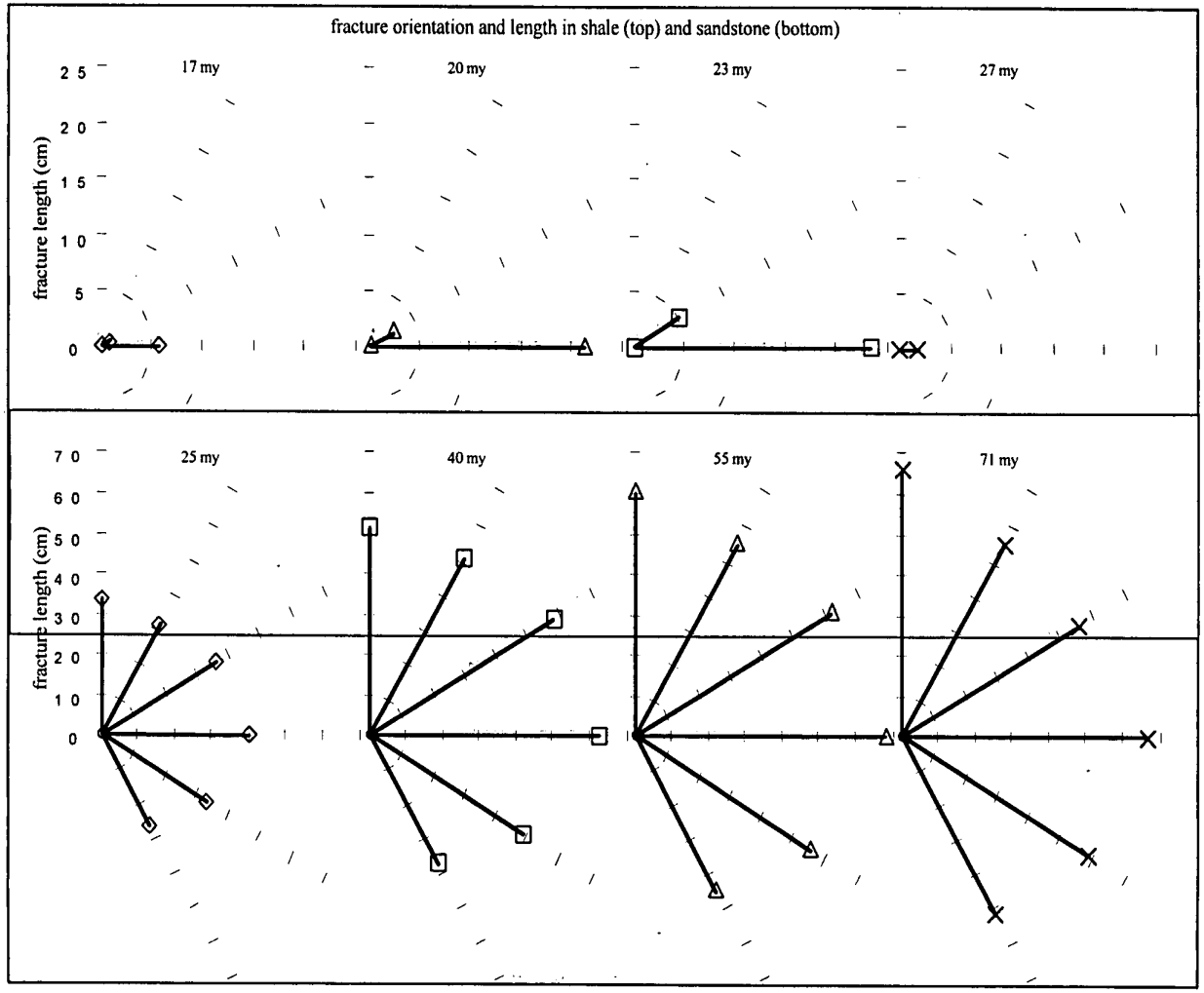

fracture orientation and length in shale (top) and sandstone (bottom)
17 my
20 my
23 my
27 my
fracture length (cm)
25
20
15
10
5
0
25 my
40 my
55 my
71 my
70
60
50
40
30
20
10
0

FIG. 8a

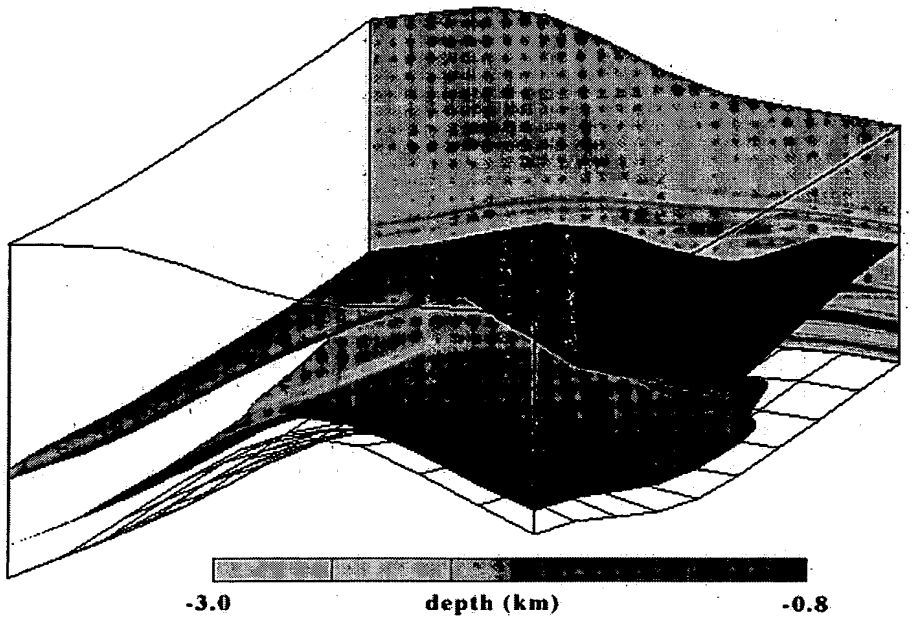


FIG. 8b

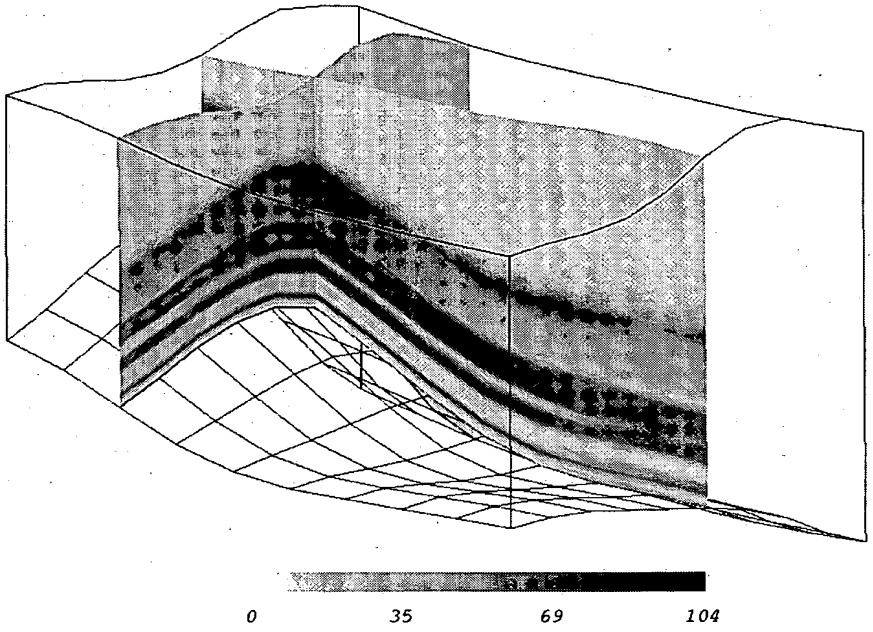


FIG. 9a

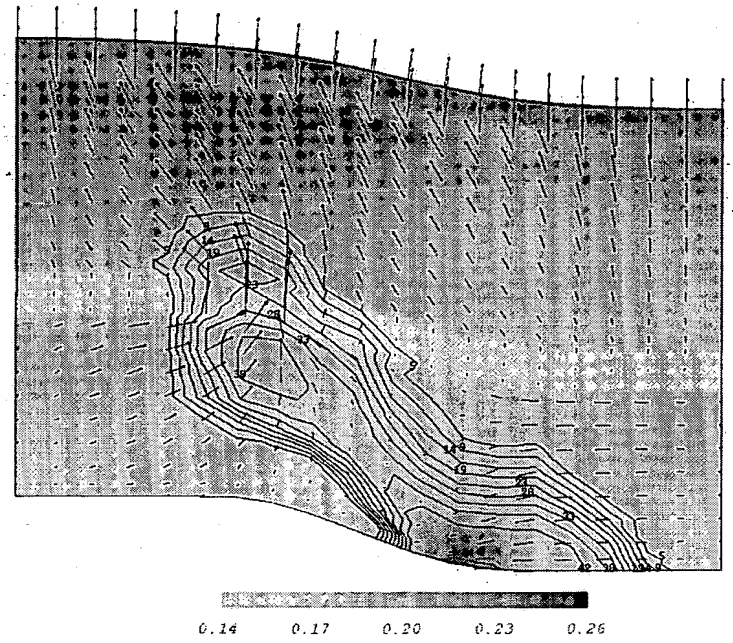


FIG. 9b

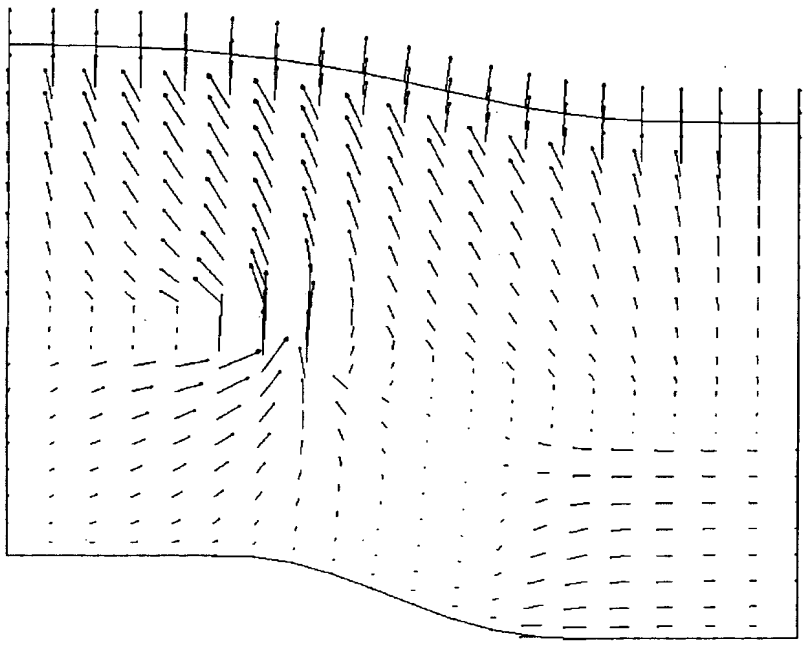


FIG. 10

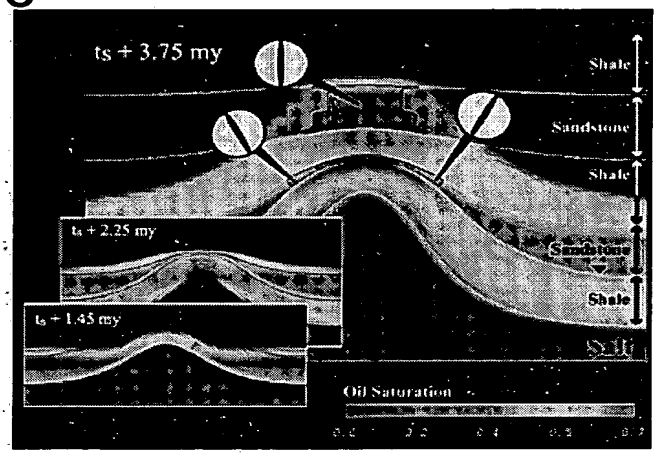

ts + 3.75 my
Shale
Sandstone
Shale
Sandstone
Shale
Salt
ts + 2.25 my
ts + 1.45 my
Oil Saturation

FIG. 11

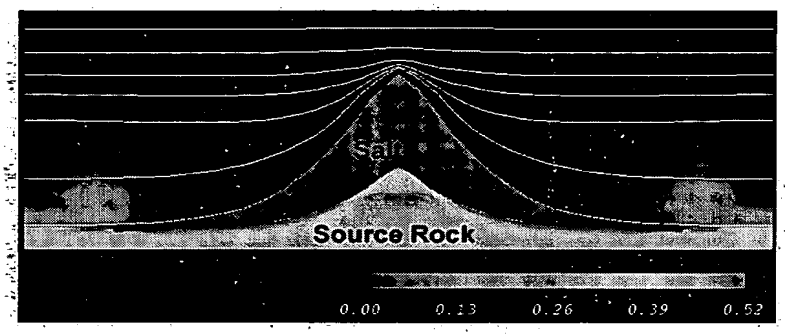


FIG. 12

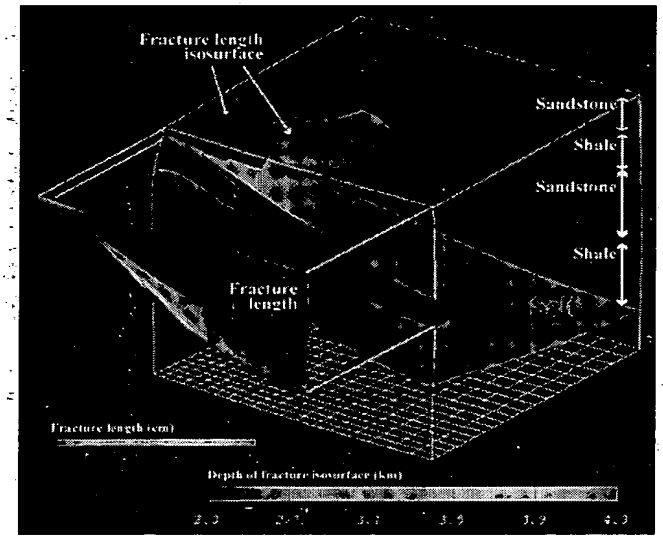

Fracture length isosurface
Sandstone
Shale
Sandstone
Shale
Fracture length
Fracture length (cm)
Depth of fracture isosurface (km)

FIG. 13

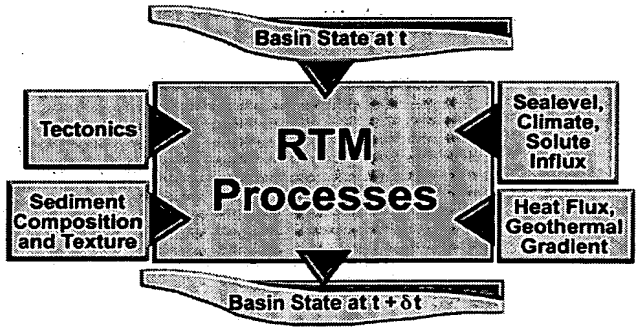

Basin State at t
Tectonics
RTM
Processes
Sealevel, Climate, Solute Influx
Sediment Composition and Texture
Heat Flux, Geothermal Gradient
Basin State at t + δt

FIG. 14a

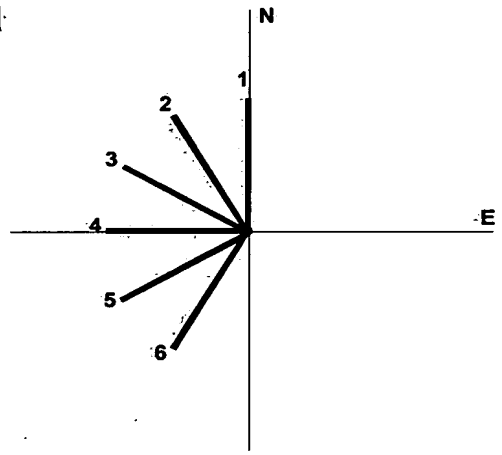


FIG. 14b

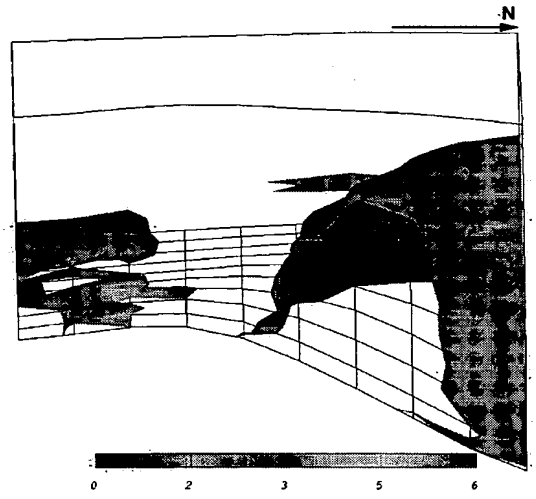


FIG. 15

Type of Data
Petroleum reserve assessment
Fracture analysis
Well log and seismic data
Tectonic and stress history
Thermal data and analysis
Stratigraphy
Data on organic content and thermal maturity
Fluid composition, pressure, and transport
Hydrothermal and magmatic fluids

FIG. 16

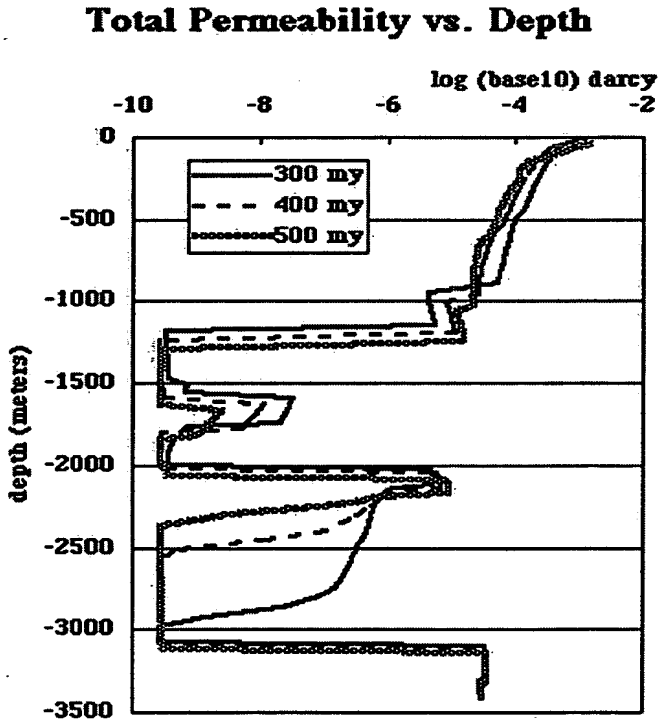

Total Permeability vs. Depth
log (base10) darcy
-10
-8
-6
-4
-2
0
-500
-1000
-1500
-2000
-2500
-3000
-3500
depth (meters)
300 my
400 my
500 my

FIG. 17

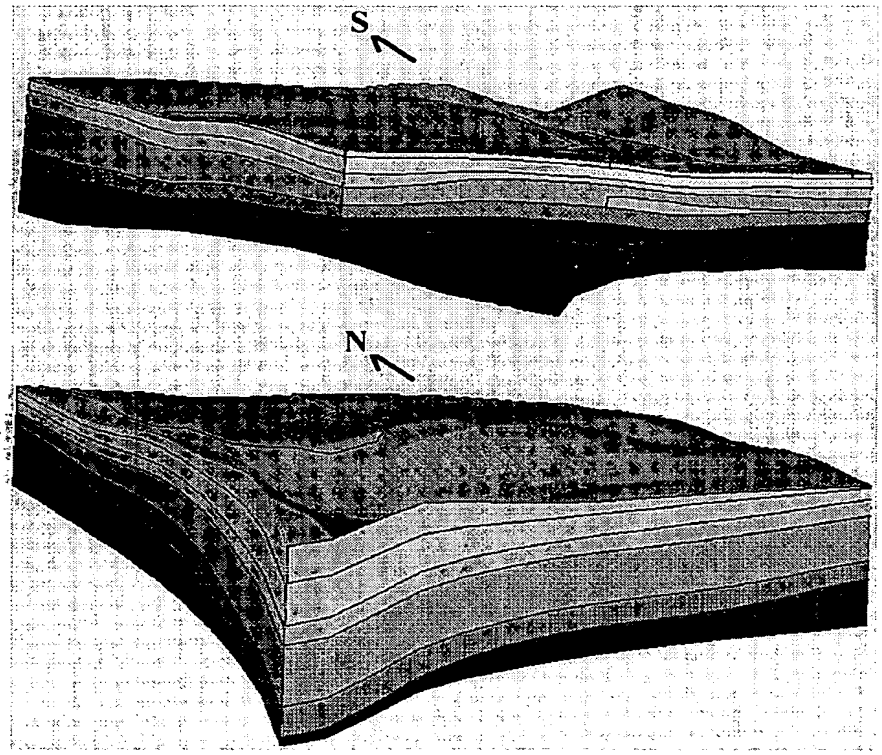


FIG. 18

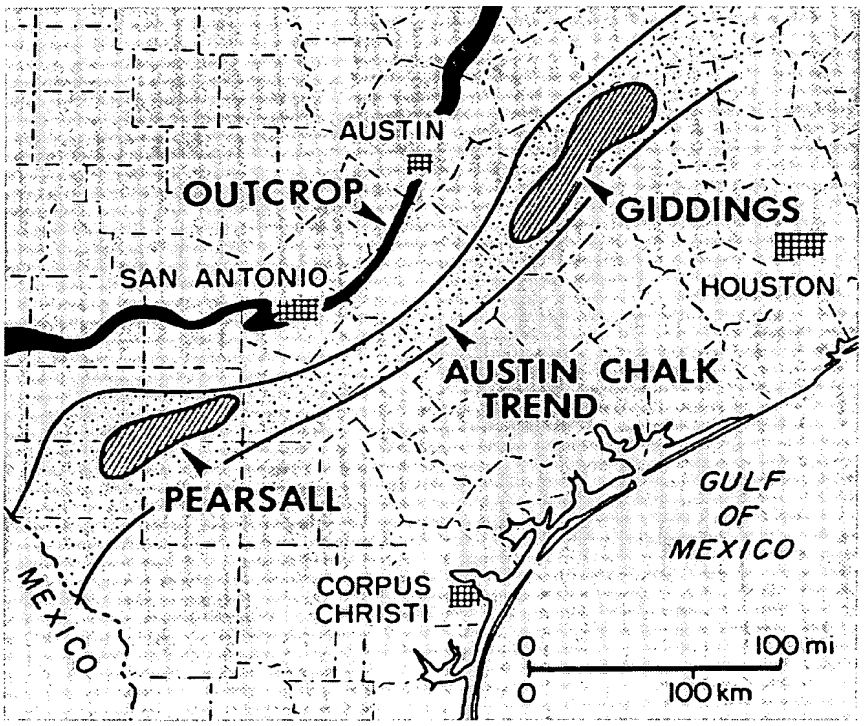

AUSTIN
OUTCROP
GIDDINGS
SAN ANTONIO
HOUSTON
AUSTIN CHALK
TREND
PEARSALL
GULF
OF
MEXICO
MEXICO
CORPUS
CHRISTI
0
100 mi
0
100 km

FIG. 19

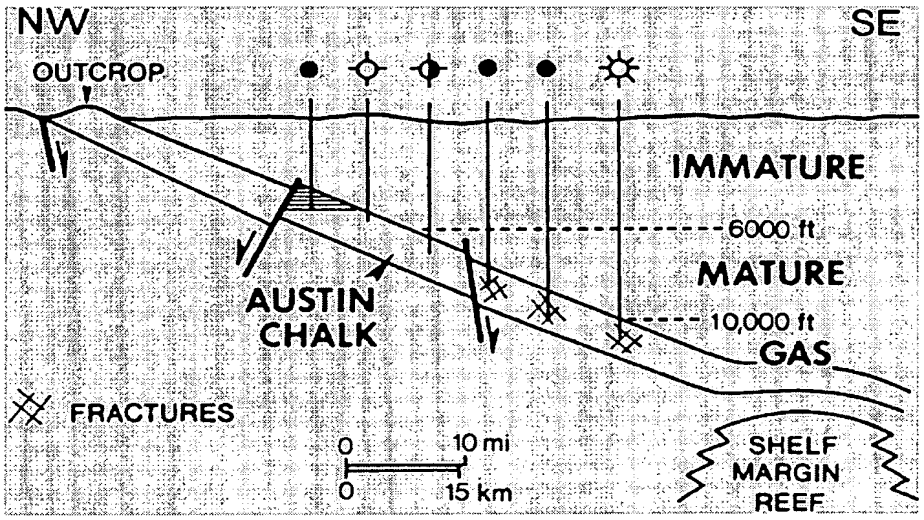
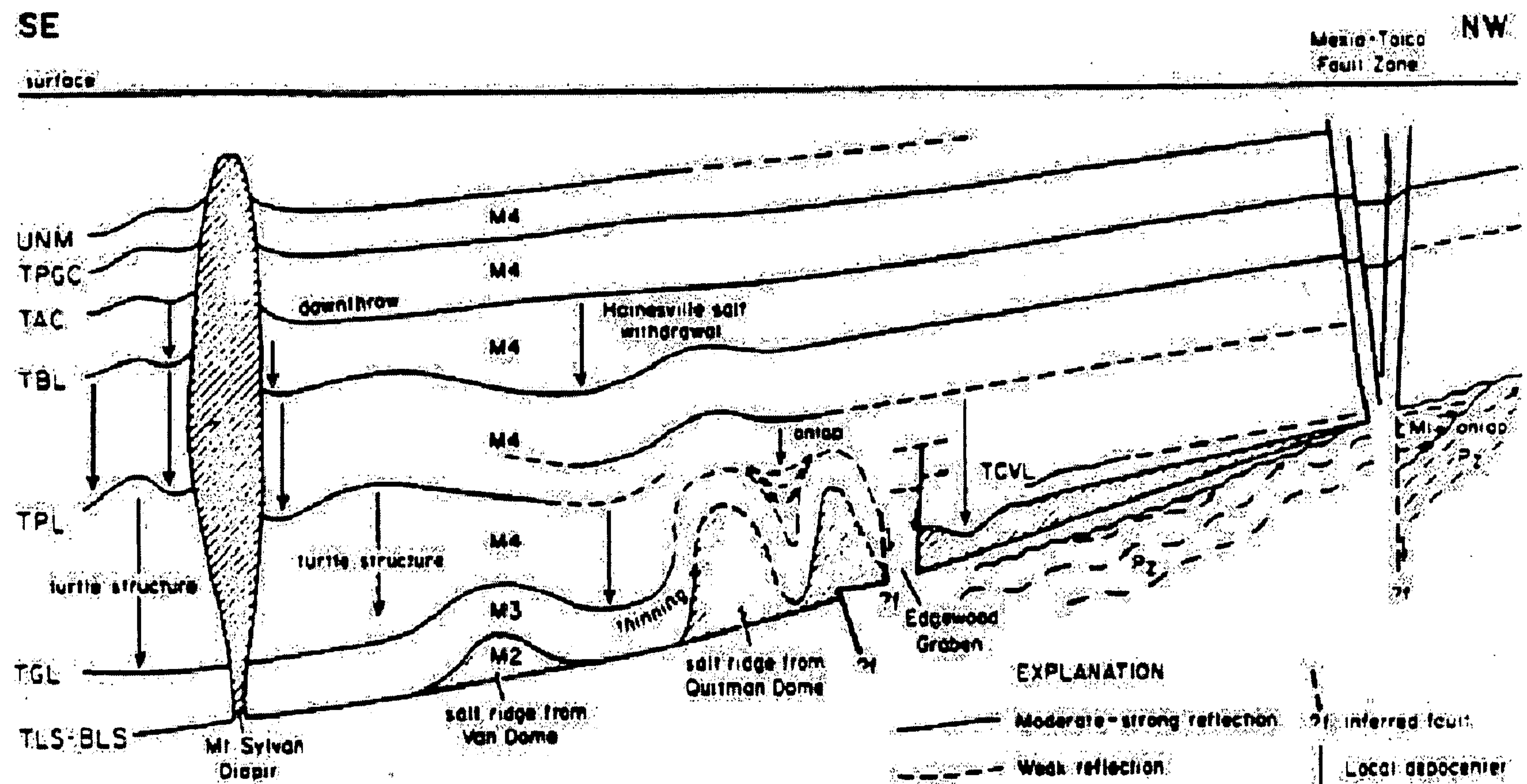

NW
SE
OUTCROP
IMMATURE
6000 ft
MATURE
10,000 ft
GAS
AUSTIN
CHALK
FRACTURES
0
10 mi
0
15 km
SHELF
MARGIN
REEF

FIG. 20


SE
NW
surface
Mexia-Talco Fault Zone
UNM
TPGC
TAC
TBL
TPL
TGL
TLS-BLS
M4
M4
M4
M4
M4
M3
M2
downthrow
Hainesville salt withdrawal
onlap
TCVL
turtle structure
turtle structure
thinning
salt ridge from Quitman Dome
salt ridge from Van Dome
Mt Sylvan Diapir
Edgewood Graben
Pz
Pz
EXPLANATION
Moderate-strong reflection
Weak reflection
Salt
?? inferred fault
Local depocenter

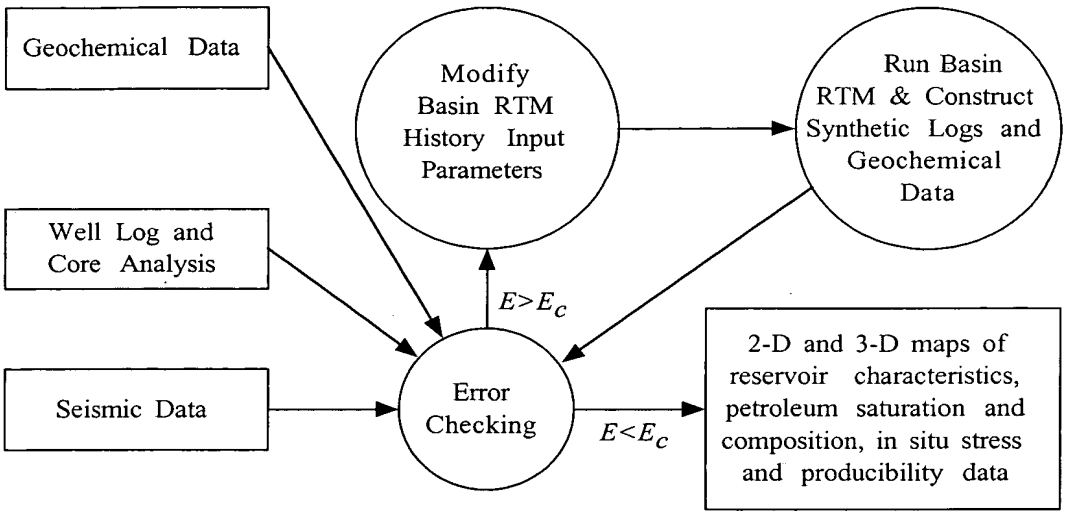

Geochemical Data
Well Log and Core Analysis
Seismic Data
Modify Basin RTM History Input Parameters
Error Checking
$E>E_c$
$E<E_c$
Run Basin RTM & Construct Synthetic Logs and Geochemical Data
2-D and 3-D maps of reservoir characteristics, petroleum saturation and composition, in situ stress and producibility data

FIG. 21

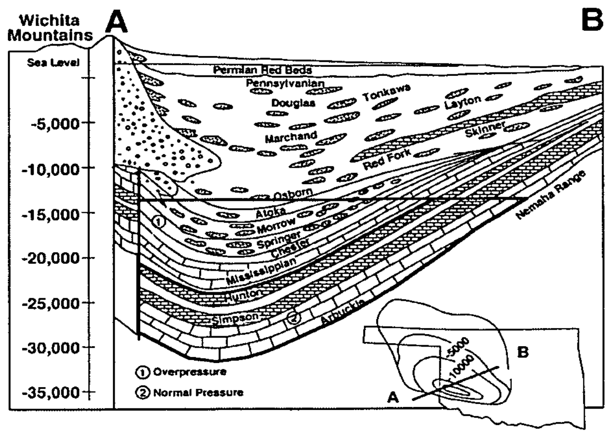


FIG. 22a

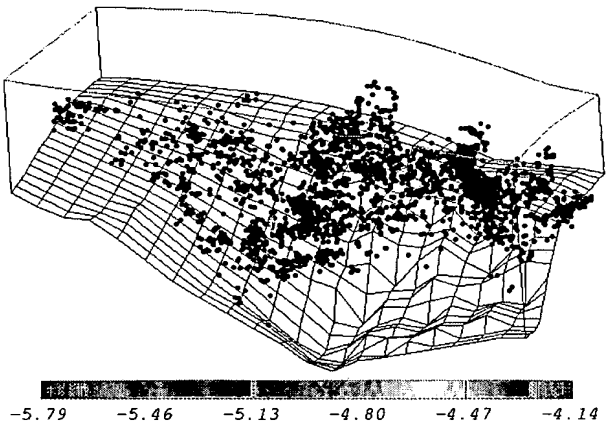


FIG. 22b

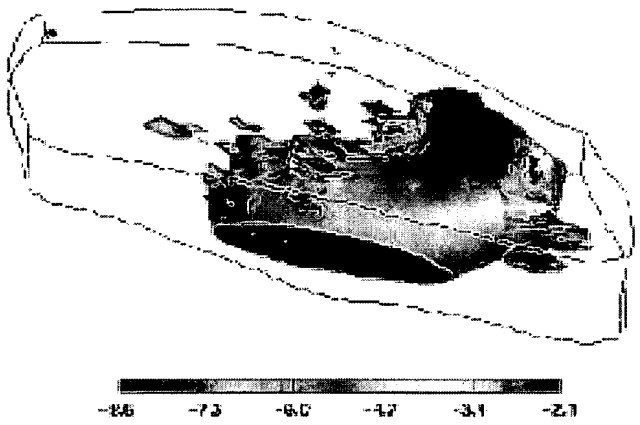


FIG. 22c

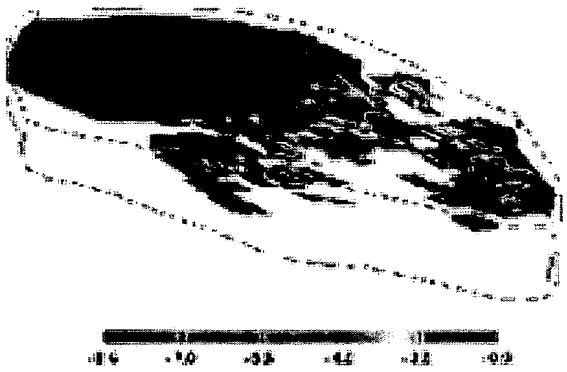


FIG. 22d

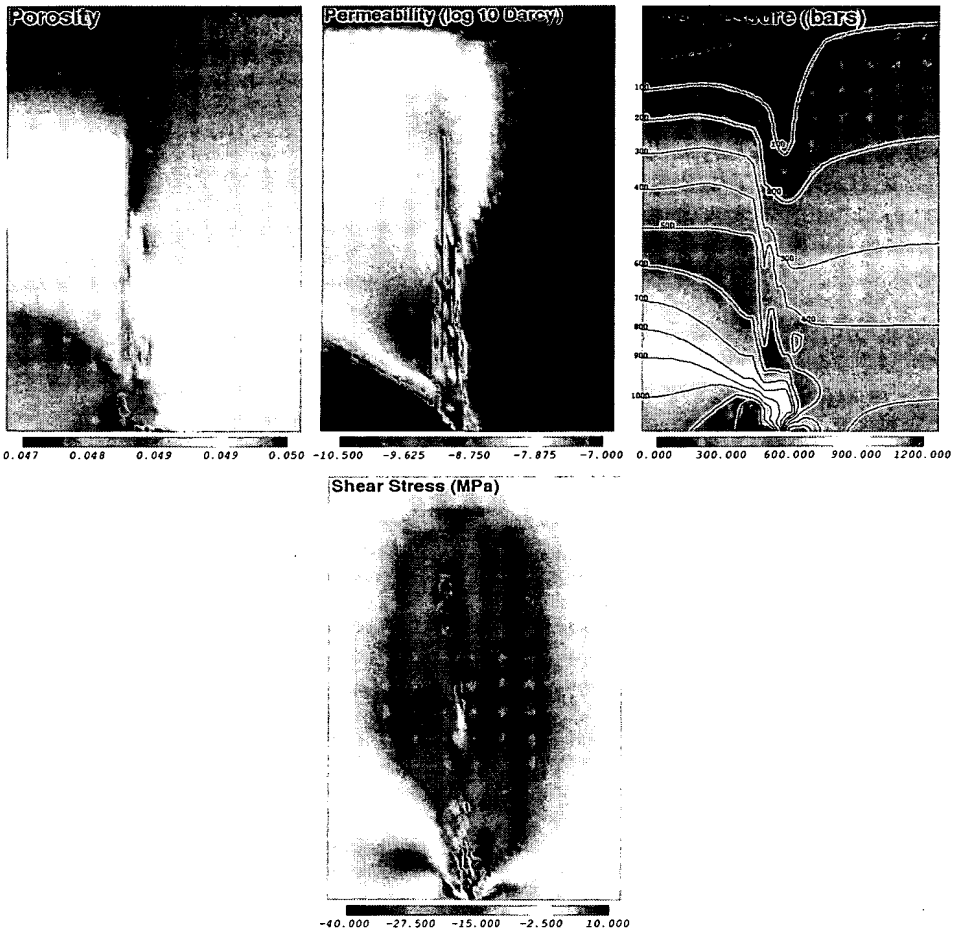


FIG. 23

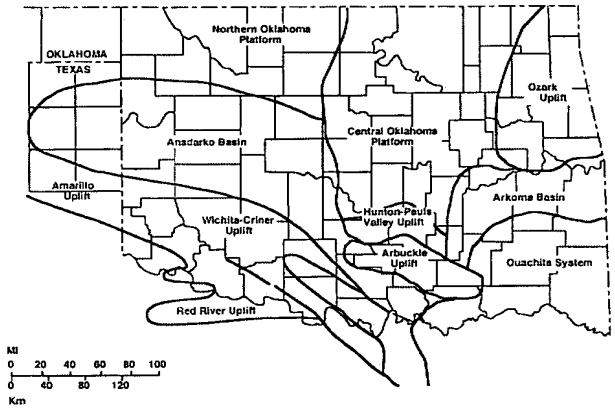

Northern Oklahoma Platform
OKLAHOMA
TEXAS
Ozark Uplift
Central Oklahoma Platform
Anadarko Basin
Amarillo Uplift
Arkoma Basin
Wichita-Criner Uplift
Hunton-Peuls Valley Uplift
Arbuckle Uplift
Ouachita System
Red River Uplift
MI
0 20 40 60 80 100
0 40 80 120
Km

FIG. 24

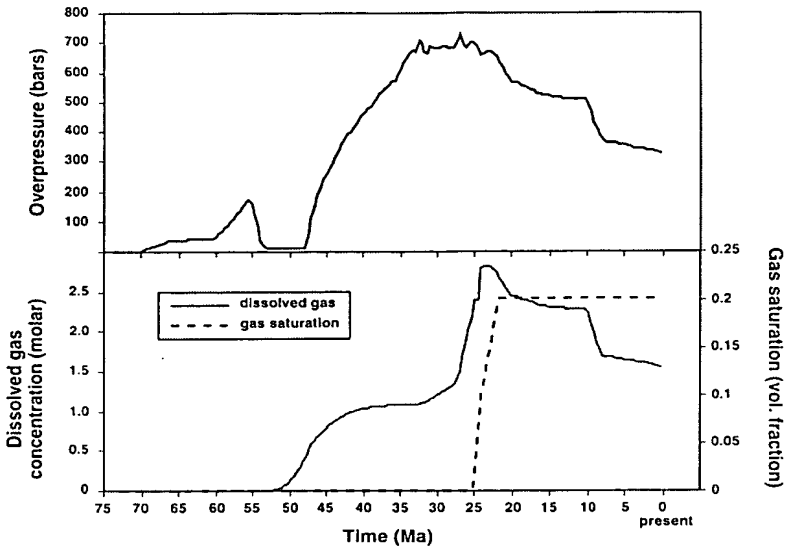

Overpressure (bars)
800
700
600
500
400
300
200
100
Dissolved gas concentration (molar)
2.5
2.0
1.5
1.0
0.5
0
dissolved gas
gas saturation
Gas saturation (vol. fraction)
0.25
0.2
0.15
0.1
0.05
0
75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
present
Time (Ma)

FIG. 25

Type of Log	Formulas	Experiments
Sonic	Bourbie et al. 1987; Tittman 1986	Bourbie et al. 1987
Density	Tittman 1986	Ahmadi and Coe 1997
Gamma	Tittman 1986	Ahmadi and Coe 1997
Resistivity	Revil et al. 1997; Tittman 1986	Penicol and Jing 1997; Donaldson et al. 1991
Permeability	Bastos et al. 1998; Tittman, 1986	Bastos et al. 1998
Neutron	Revil et al. 1997; Tittman 1986	
SP	Revil et al. 1997; Tittman 1986	

FIG. 26

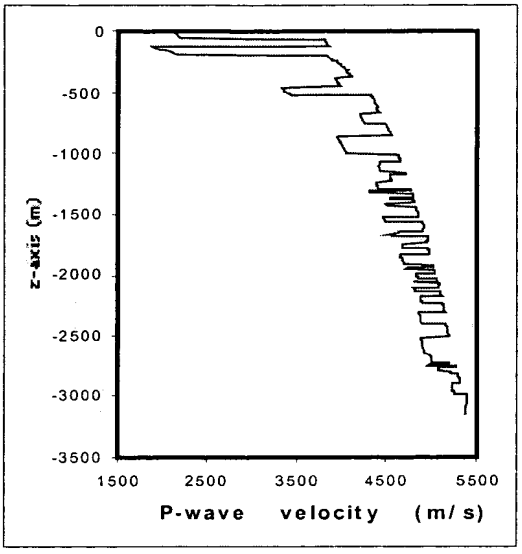

0
-500
-1000
-1500
-2000
-2500
-3000
-3500
z-axis (m)
1500
2500
3500
4500
5500
P-wave velocity (m/s)

FIG. 27a

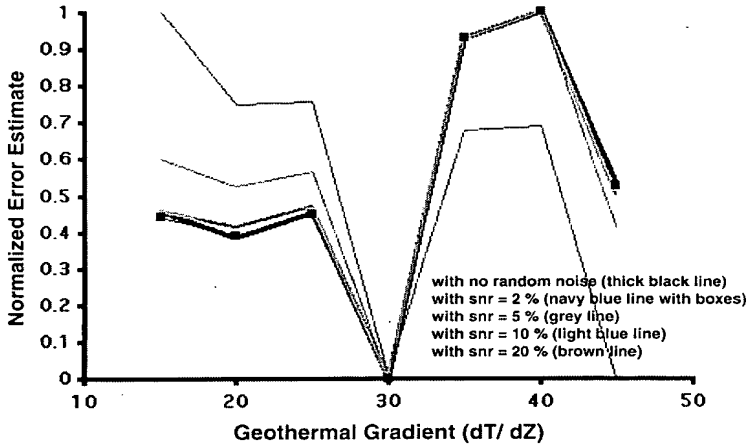

Normalized Error Estimate
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10
20
30
40
50
Geothermal Gradient (dT/ dZ)
with no random noise (thick black line)
with snr = 2 % (navy blue line with boxes)
with snr = 5 % (grey line)
with snr = 10 % (light blue line)
with snr = 20 % (brown line)

FIG. 27b

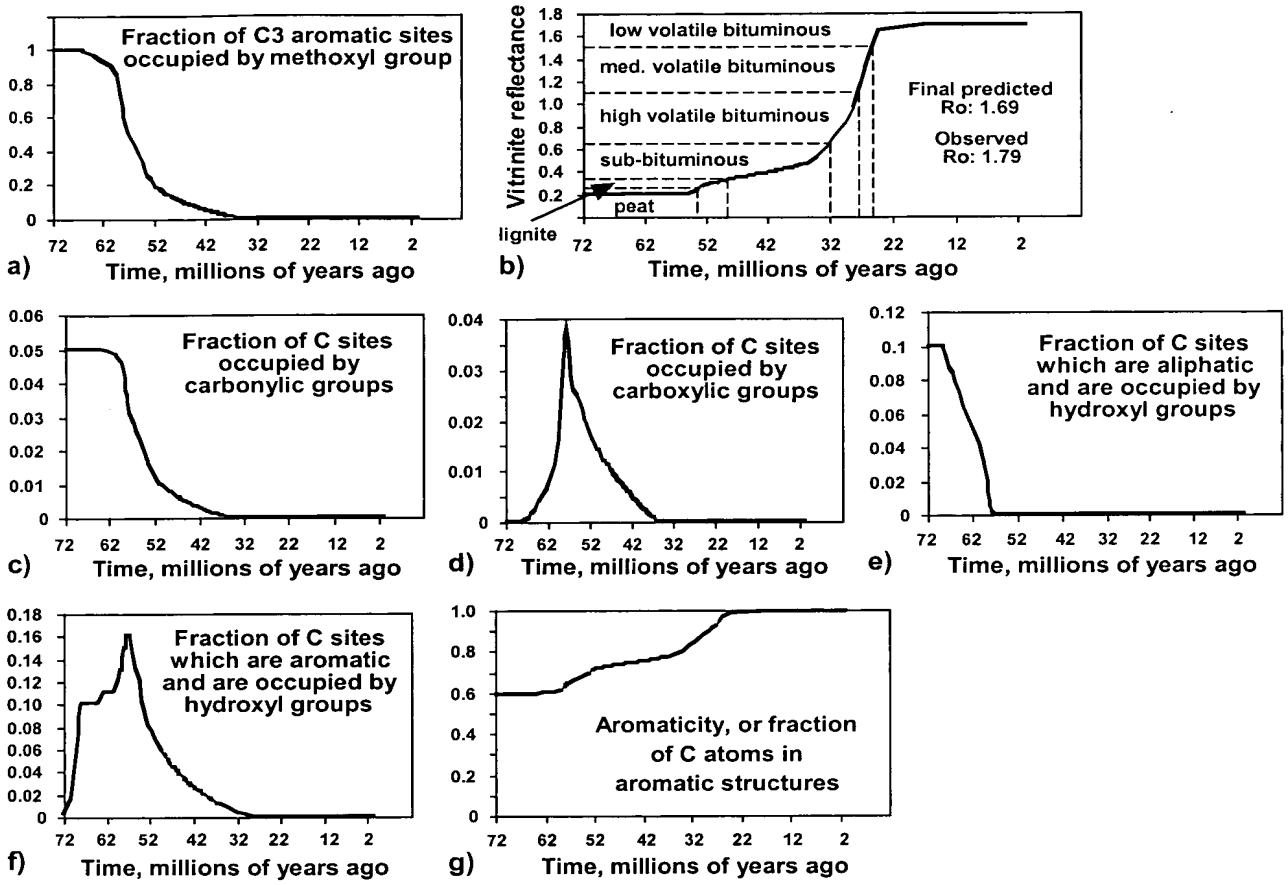

Fraction of C3 aromatic sites occupied by methoxyl group
a)
Time, millions of years ago
Vitrinite reflectance
low volatile bituminous
med. volatile bituminous
high volatile bituminous
sub-bituminous
peat
lignite
Final predicted Ro: 1.69
Observed Ro: 1.79
b)
Time, millions of years ago
Fraction of C sites occupied by carbonylic groups
c)
Time, millions of years ago
Fraction of C sites occupied by carboxylic groups
d)
Time, millions of years ago
Fraction of C sites which are aliphatic and are occupied by hydroxyl groups
e)
Time, millions of years ago
Fraction of C sites which are aromatic and are occupied by hydroxyl groups
f)
Time, millions of years ago
Aromaticity, or fraction of C atoms in aromatic structures
g)
Time, millions of years ago

FIG. 28

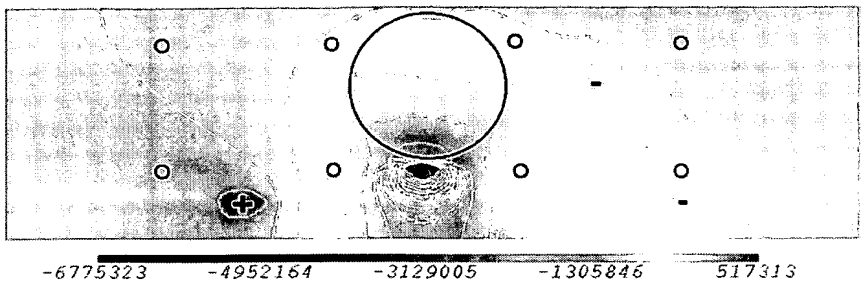


FIG. 29a

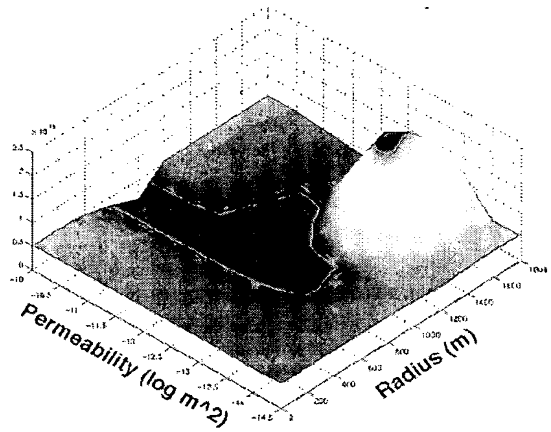


FIG. 29b

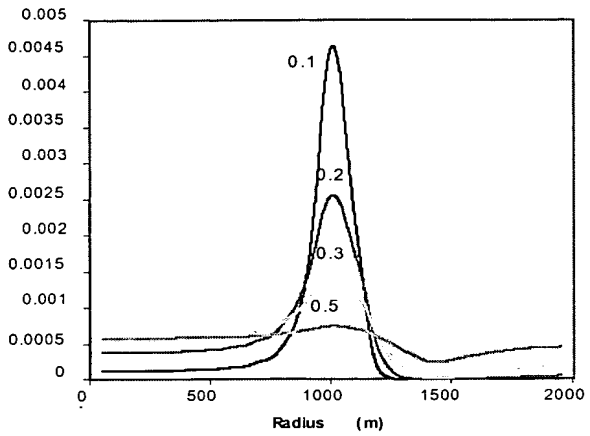

0.005
0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
0.1
0.2
0.3
0.5
0
500
1000
1500
2000
Radius (m)

FIG. 29c

Stratigraphic Interval	Cores	Thin Sections
1. Missourian- Virgilian	20	122
2. Desmoinesian	46	502
3. Morrowan	51	655
4. Springeran	8	79
5. Hunton		
6. Woodford	7	57
7. Simpson		
8. Arbuckle		
Total	**166**	**2096**

FIG. 30a

Data Type	# of Analysis
Wire-line logs	3,000
Pressure Data	5,000
Capillary Pressure	15
Vitrinite Reflectance	72
Isotopic Analysis	52
Fluid Inclusion	267
Seismic Lines	2
Tectonic History (Time Depth Profiles)	12
Permeability	35
Fracture Analysis	166

FIG. 30b

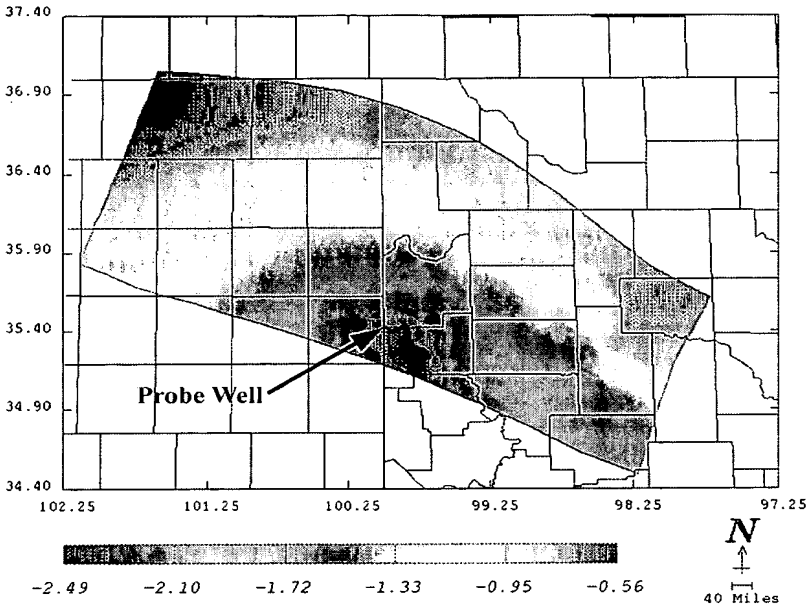
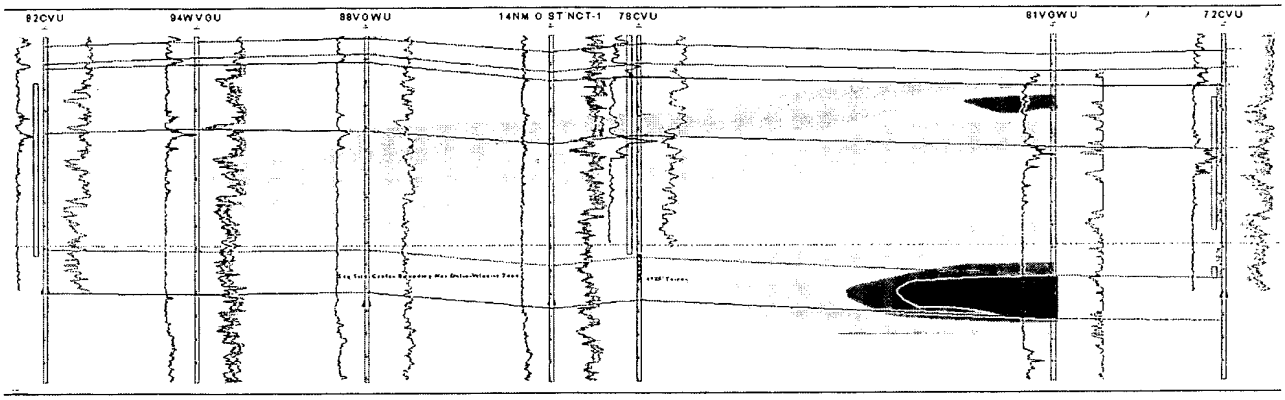

37.40
36.90
36.40
35.90
35.40
34.90
34.40
102.25
101.25
100.25
99.25
98.25
97.25
Probe Well
-2.49
-2.10
-1.72
-1.33
-0.95
-0.56
N
40 Miles

FIG. 31

Section 36 Crosswell Data - Velocity Change Due To CO_2, VGWU #94 to VGWU #81



VGWU #94 CVU #78 VGWU #81

FIG. 32

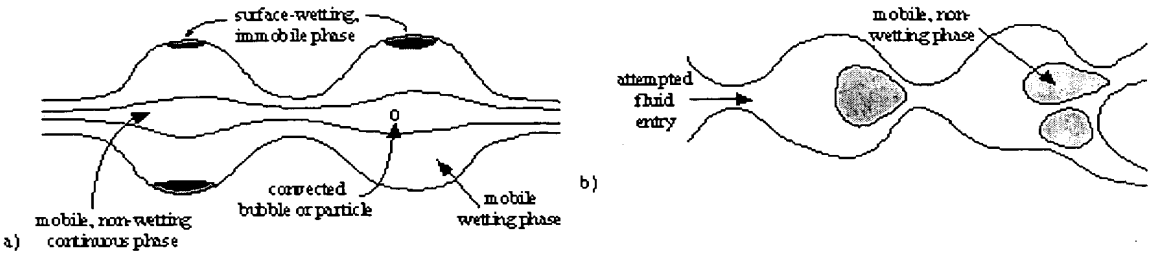

surface-wetting, immobile phase
mobile, non-wetting continuous phase
connected bubble or particle
mobile wetting phase
a)
b)
attempted fluid entry
mobile, non-wetting phase

FIG. 33

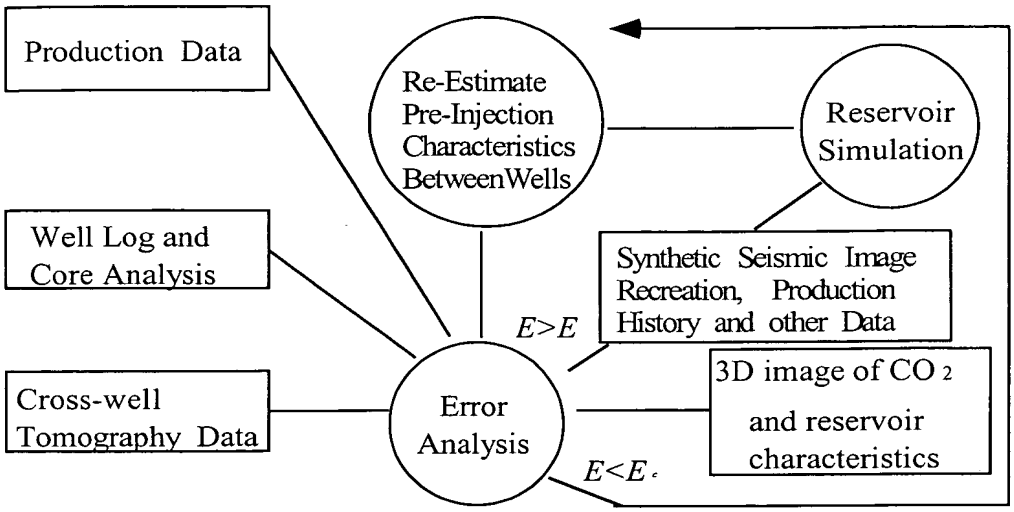

Production Data
Well Log and Core Analysis
Cross-well Tomography Data
Re-Estimate Pre-Injection Characteristics BetweenWells
Reservoir Simulation
Synthetic Seismic Image Recreation, Production History and other Data
E>E
Error Analysis
3D image of CO 2 and reservoir characteristics
E<E.

FIG. 34

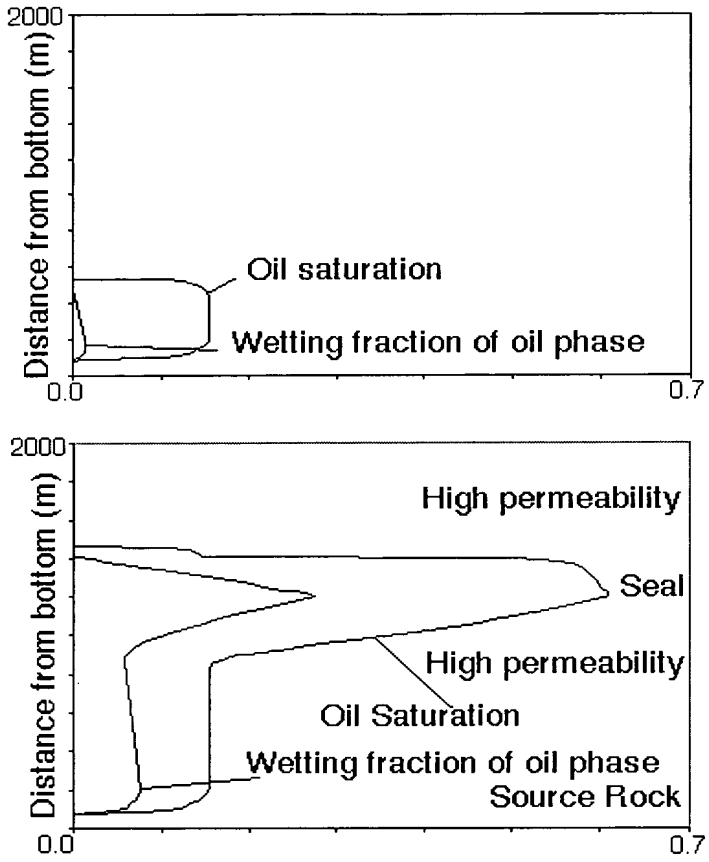

2000
Distance from bottom (m)
Oil saturation
Wetting fraction of oil phase
0.0
0.7
2000
Distance from bottom (m)
High permeability
Seal
High permeability
Oil Saturation
Wetting fraction of oil phase
Source Rock
0.0
0.7

FIG. 35

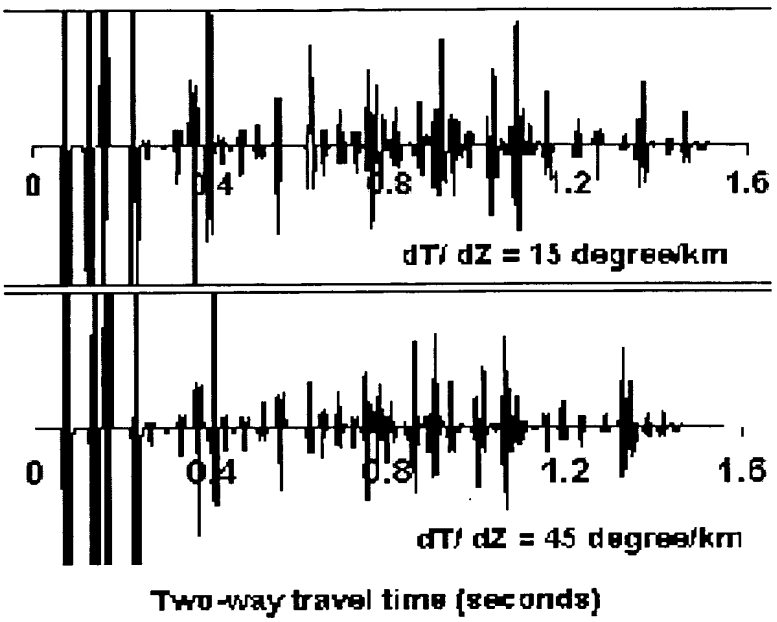

0
0.4
0.8
1.2
1.6
dT/ dZ = 15 degree/km
0
0.4
0.8
1.2
1.6
dT/ dZ = 45 degree/km
Two-way travel time (seconds)

FIG. 36

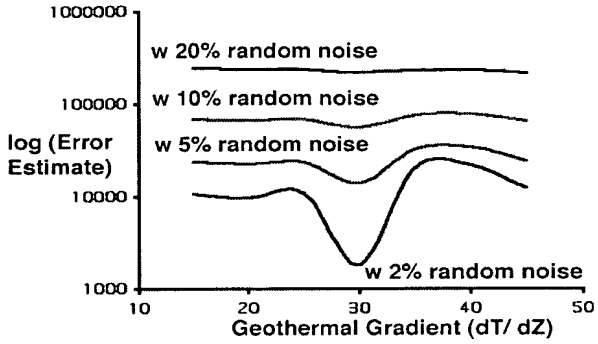

1000000
100000
10000
1000
log (Error Estimate)
w 20% random noise
w 10% random noise
w 5% random noise
w 2% random noise
10
20
30
40
50
Geothermal Gradient (dT/ dZ)

FIG. 37

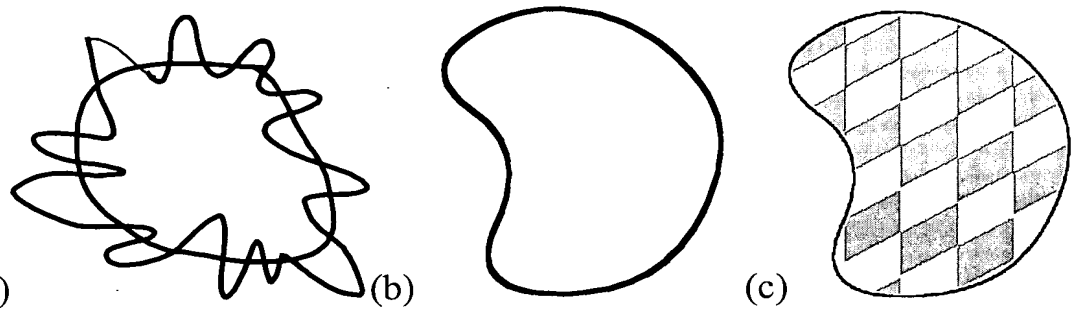


FIG. 38

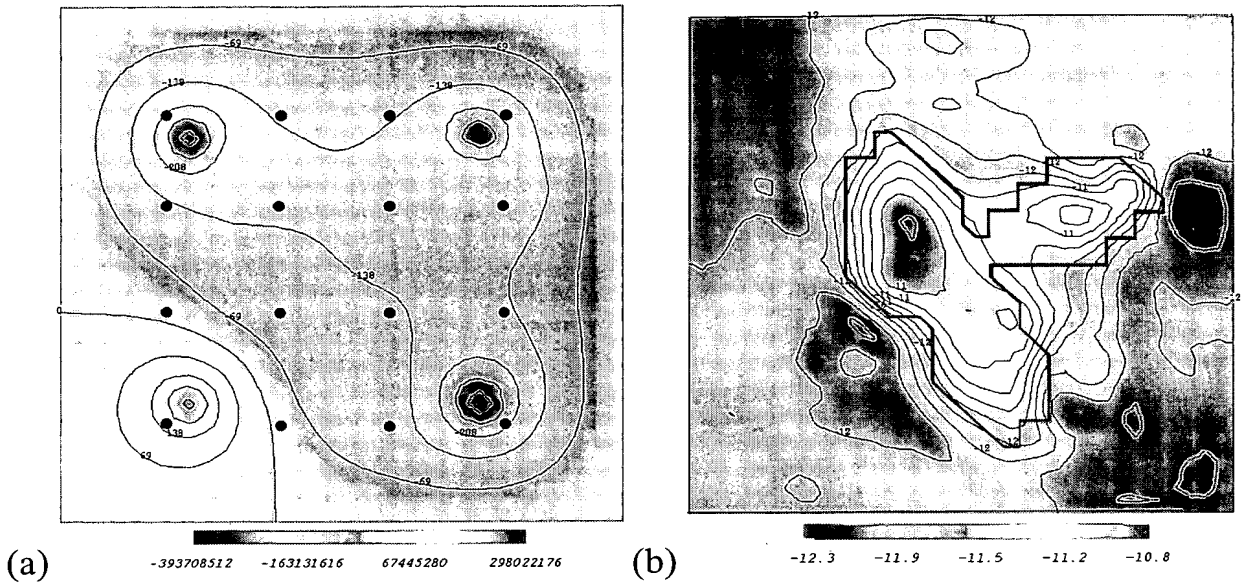

(a)
-393708512
-163131616
67445280
298022176
(b)
-12.3
-11.9
-11.5
-11.2
-10.8

FIG. 39

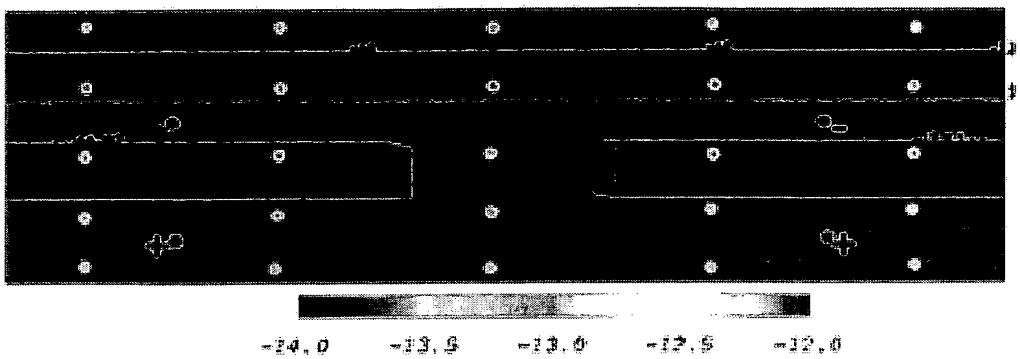


FIG. 40a

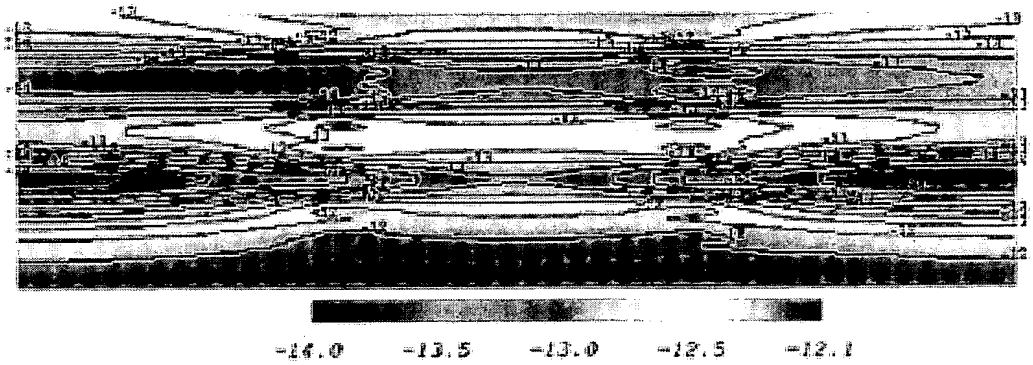


FIG. 40b

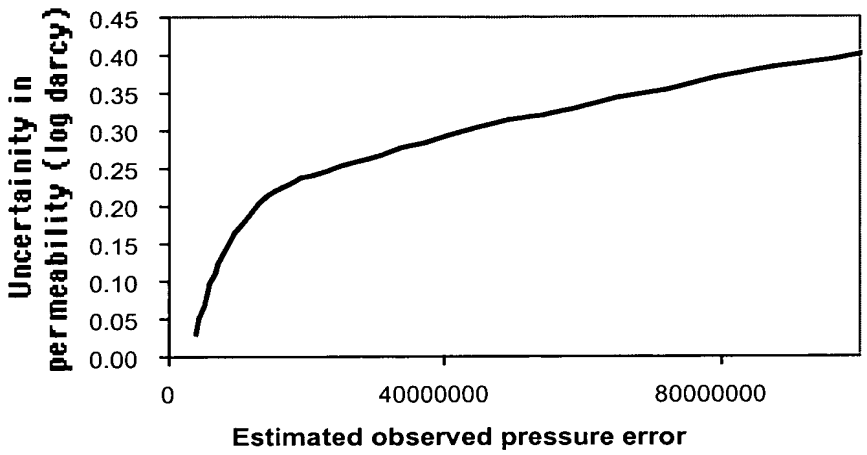

Uncertainity in permeability (log darcy)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
40000000
80000000
Estimated observed pressure error

FIG. 40c

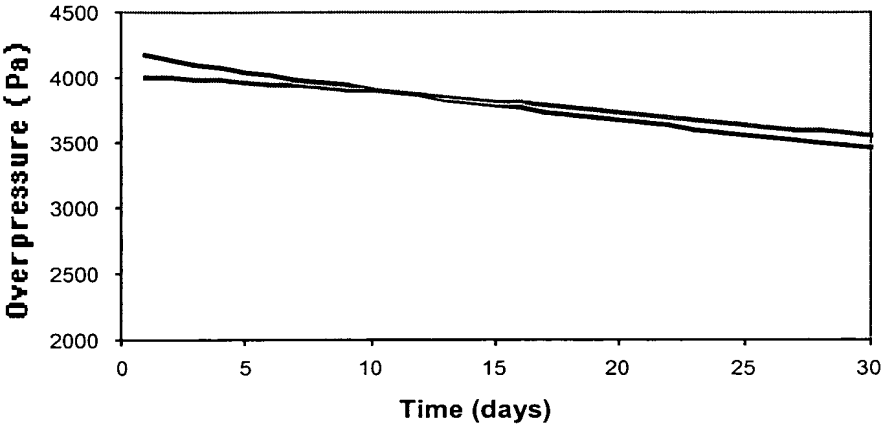

4500
4000
3500
3000
2500
2000
Overpressure (Pa)
0
5
10
15
20
25
30
Time (days)

FIG. 41

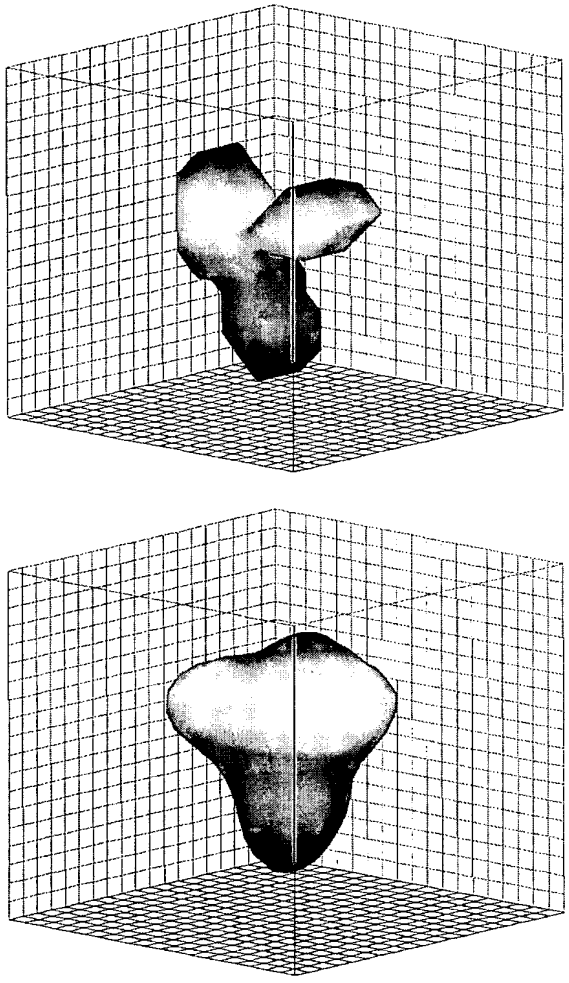


FIG. 42

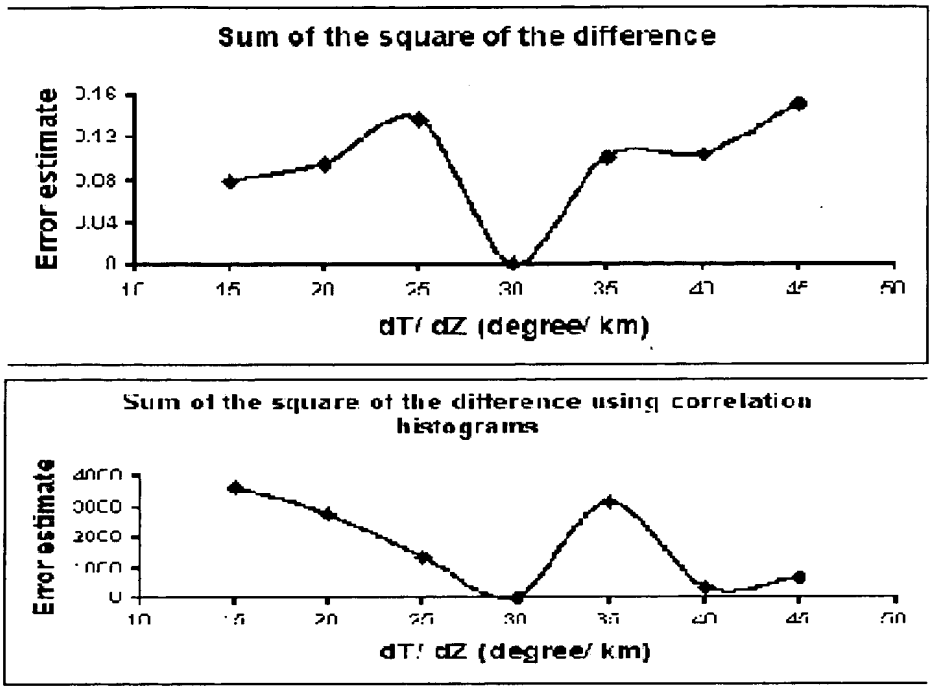

Sum of the square of the difference
Error estimate
0.16
0.12
0.08
0.04
0
10
15
20
25
30
35
40
45
50
dT/ dZ (degree/ km)
Sum of the square of the difference using correlation histograms
Error estimate
4000
3000
2000
1000
0
10
15
20
25
30
35
40
45
50
dT/ dZ (degree/ km)

FIG. 43

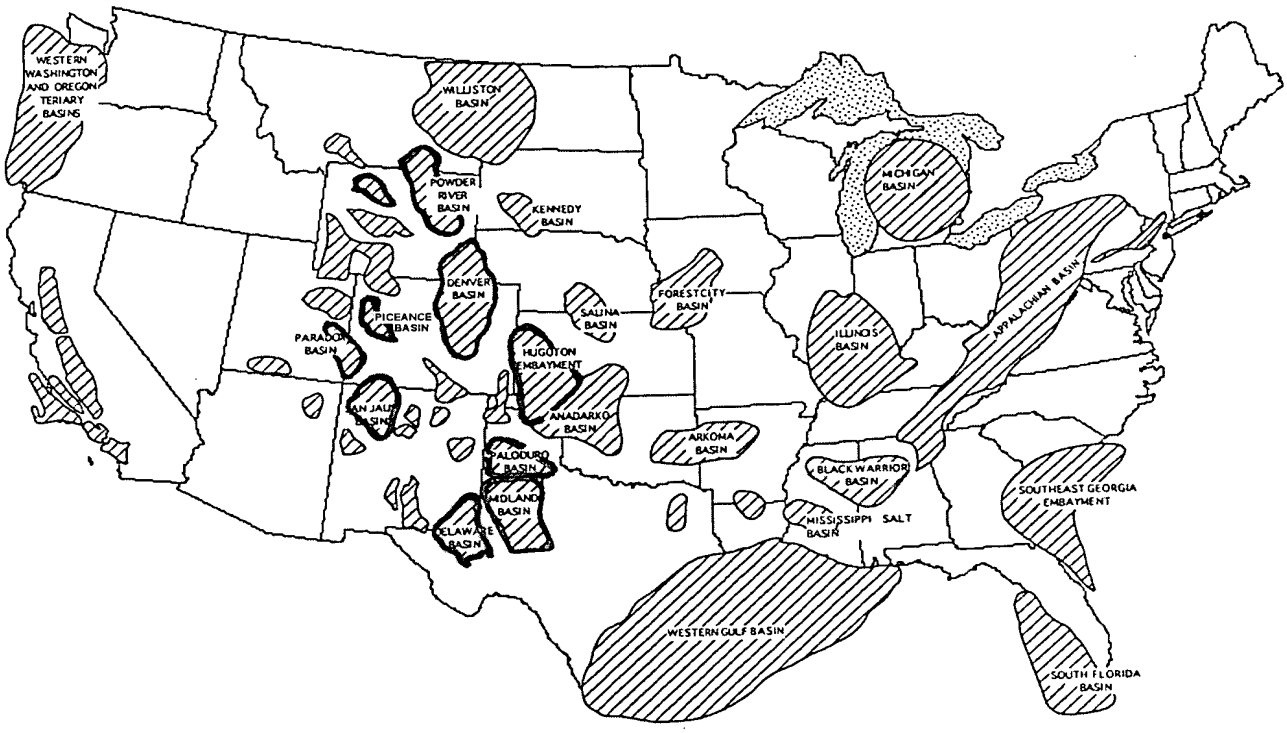

WESTERN WASHINGTON AND OREGON TERIARY BASINS
WILLISTON BASIN
POWDER RIVER BASIN
KENNEDY BASIN
MICHIGAN BASIN
DENVER BASIN
PICEANCE BASIN
PARADOX BASIN
SALINA BASIN
FORESTCITY BASIN
ILLINOIS BASIN
APPALACHIAN BASIN
HUGOTON EMBAYMENT
SAN JAUN BASIN
ANADARKO BASIN
ARKOMA BASIN
PALODURO BASIN
BLACK WARRIOR BASIN
SOUTHEAST GEORGIA EMBAYMENT
MIDLAND BASIN
MISSISSIPPI SALT BASIN
CLAWATER BASIN
WESTERN GULF BASIN
SOUTH FLORIDA BASIN

FIG. 44

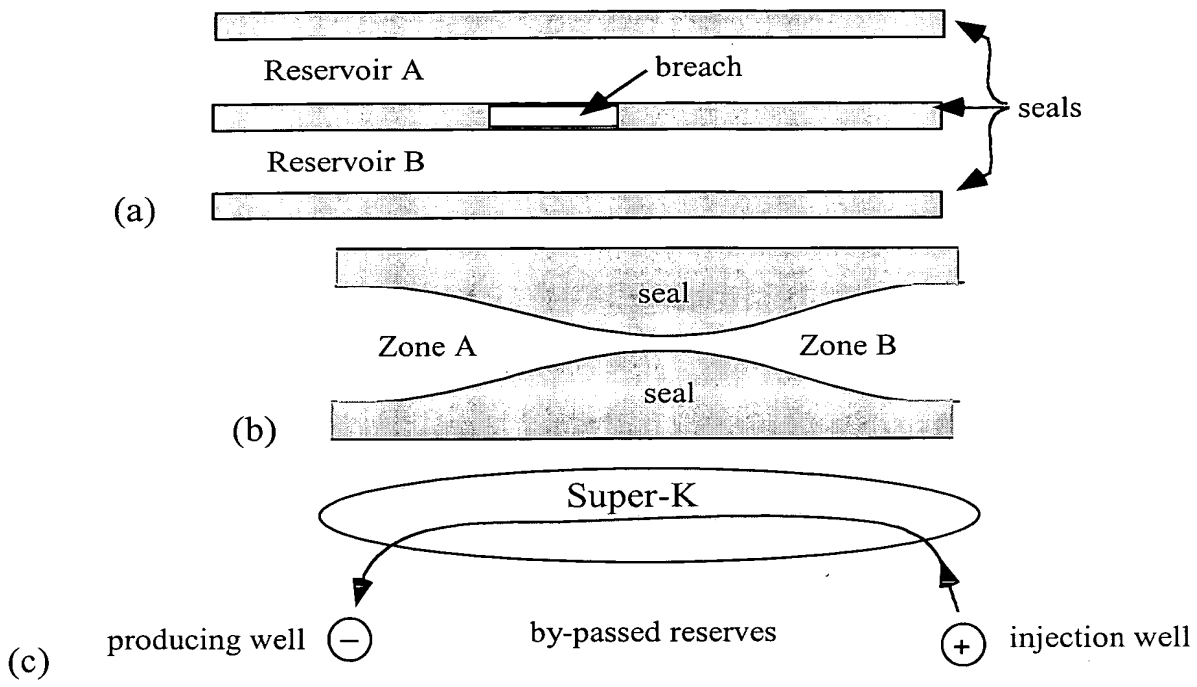

Reservoir A
breach
seals
Reservoir B
(a)
seal
Zone A
Zone B
seal
(b)
Super-K
producing well
by-passed reserves
injection well
(c)

FIG. 45

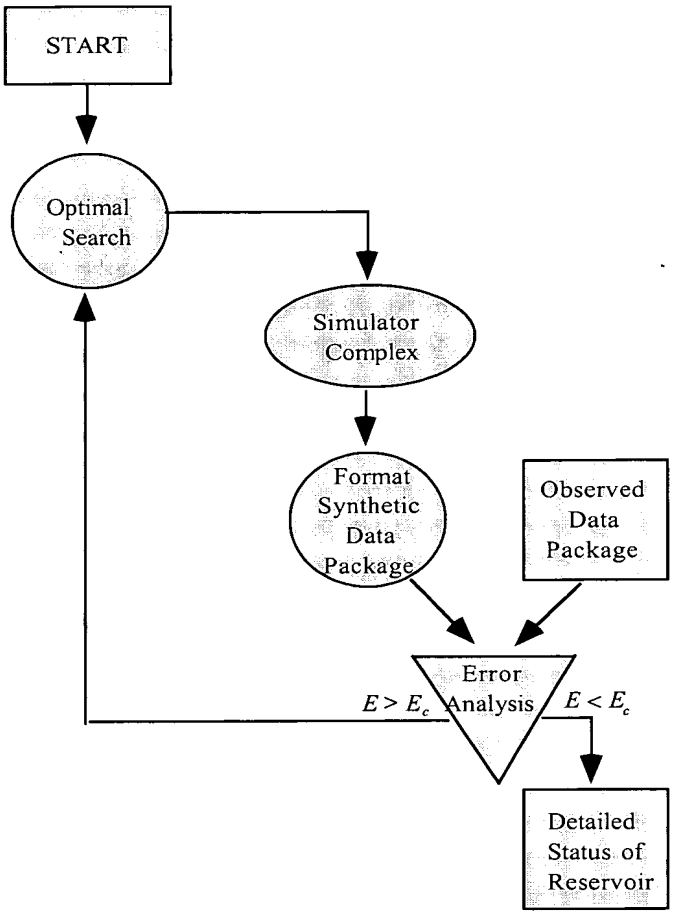

START
Optimal Search
Simulator Complex
Format Synthetic Data Package
Observed Data Package
Error Analysis
$E > E_c$
$E < E_c$
Detailed Status of Reservoir

FIG. 46

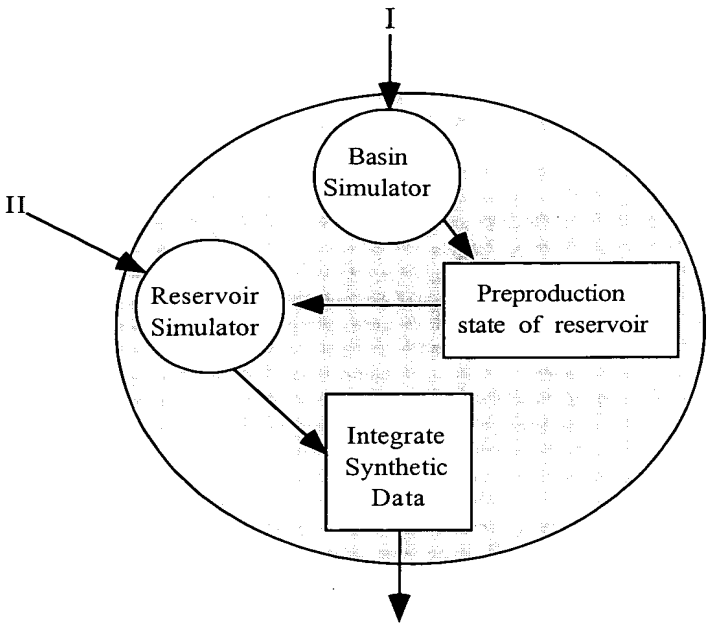
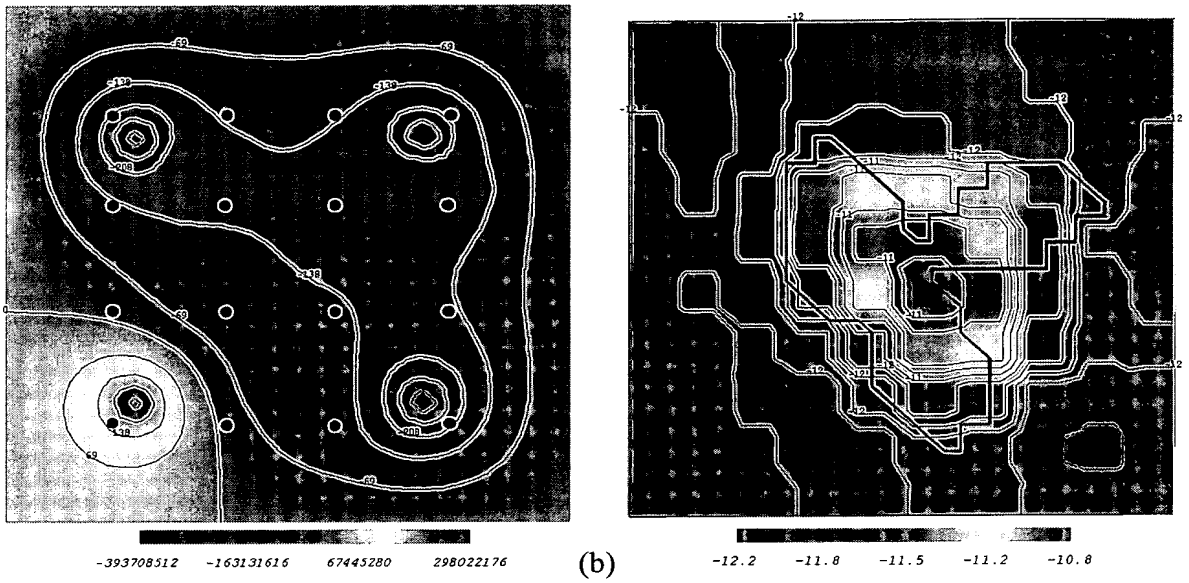
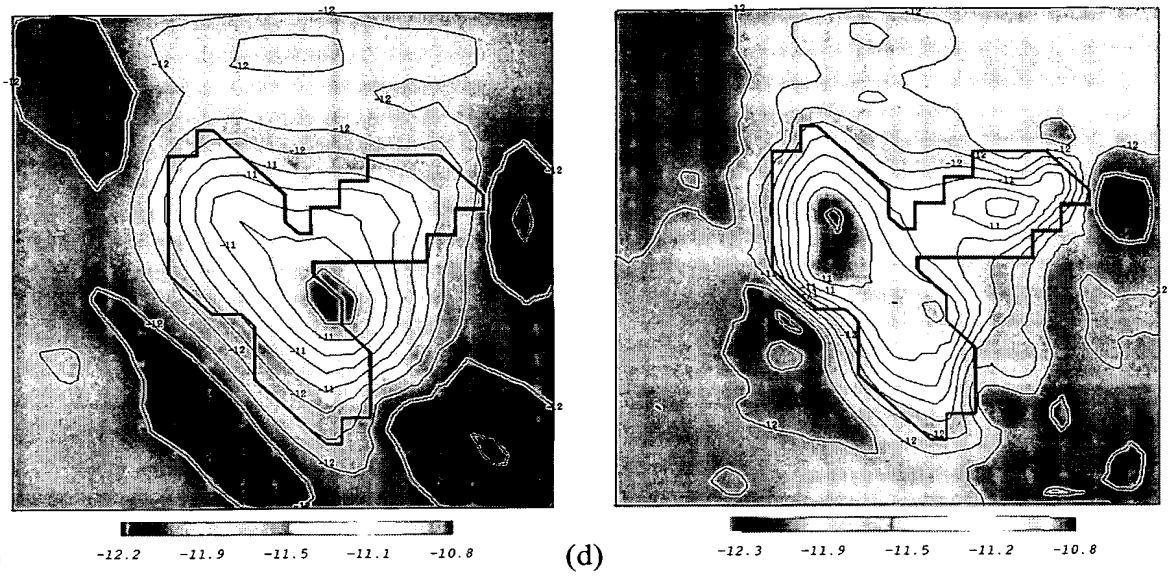

I
II
Basin Simulator
Reservoir Simulator
Preproduction state of reservoir
Integrate Synthetic Data

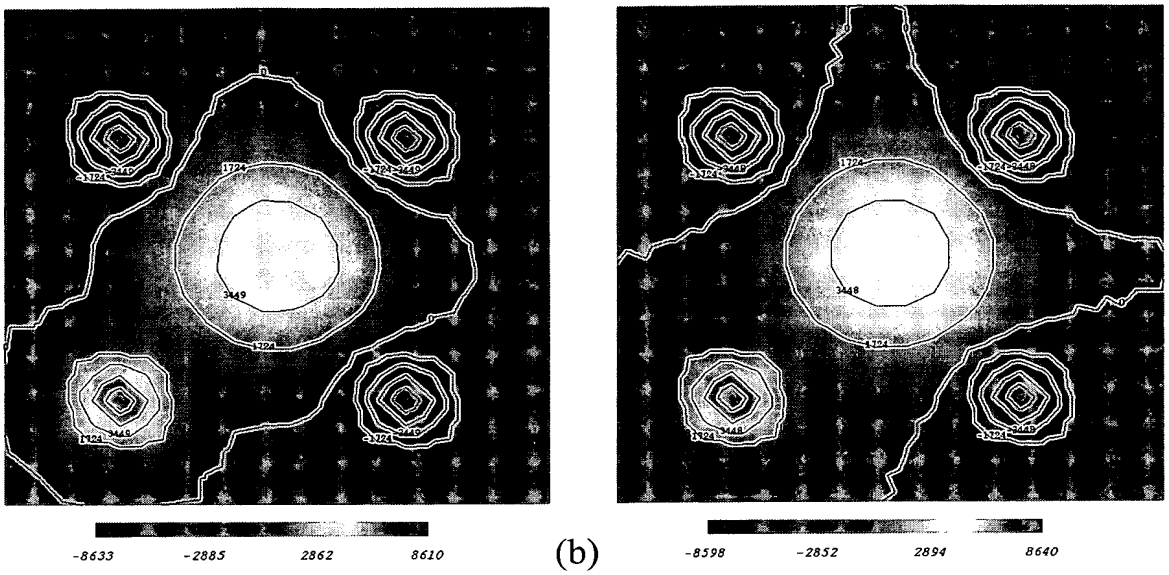
FIG. 47

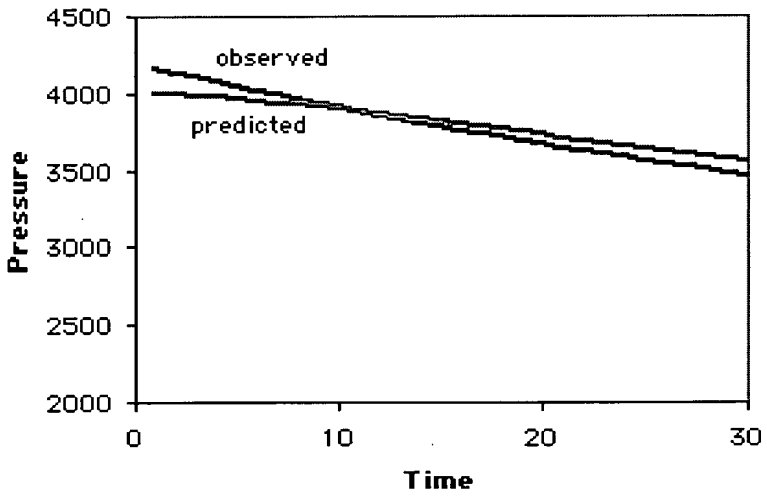


FIGs. 48a and 48b



FIGs. 48c and 48d


(a)
-8633
-2885
2862
8610
(b)
-8598
-2852
2894
8640


4500
4000
3500
3000
2500
2000
Pressure
observed
predicted
0
10
20
30
Time

(c)

FIG. 49

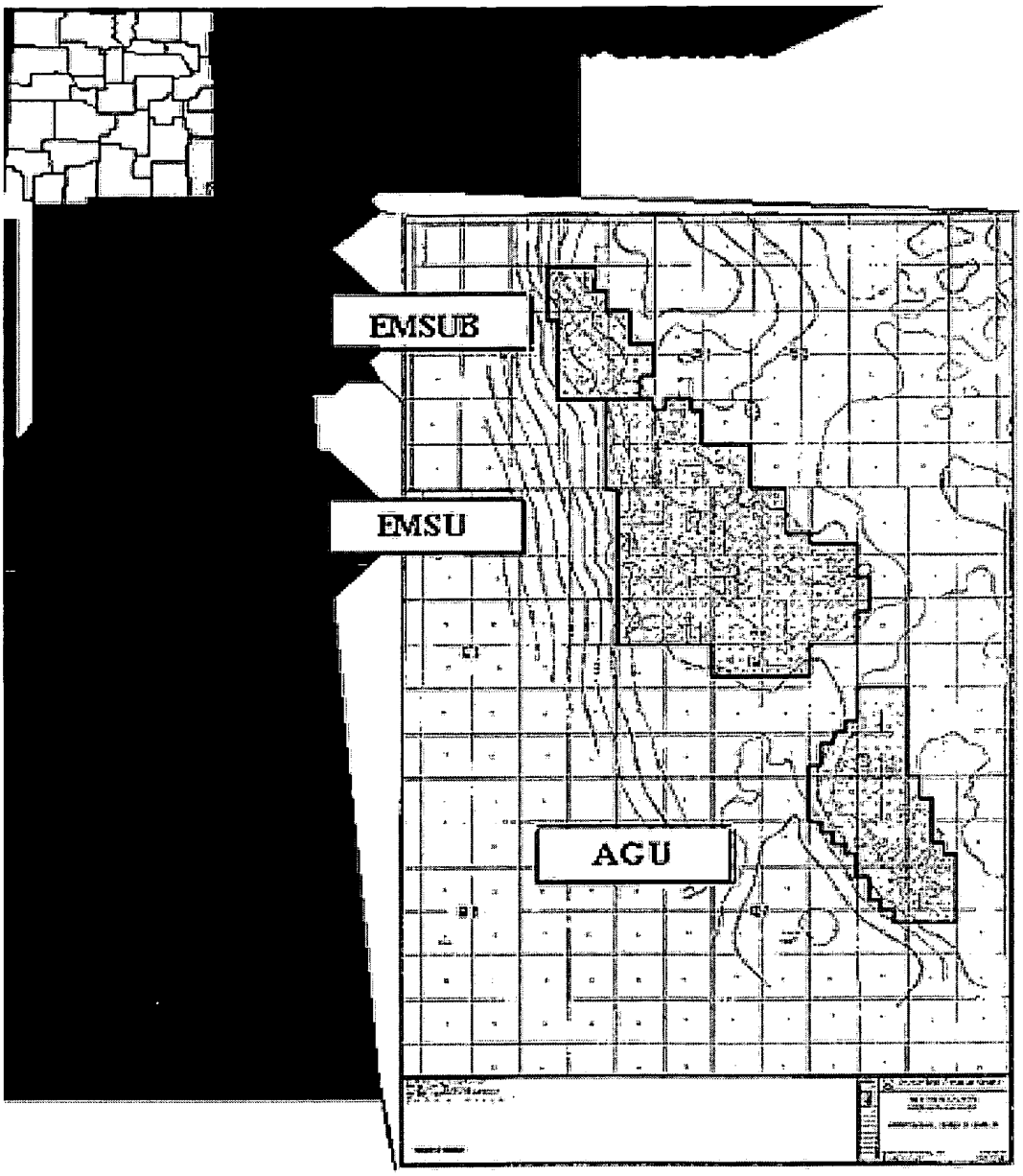


FIG. 50a

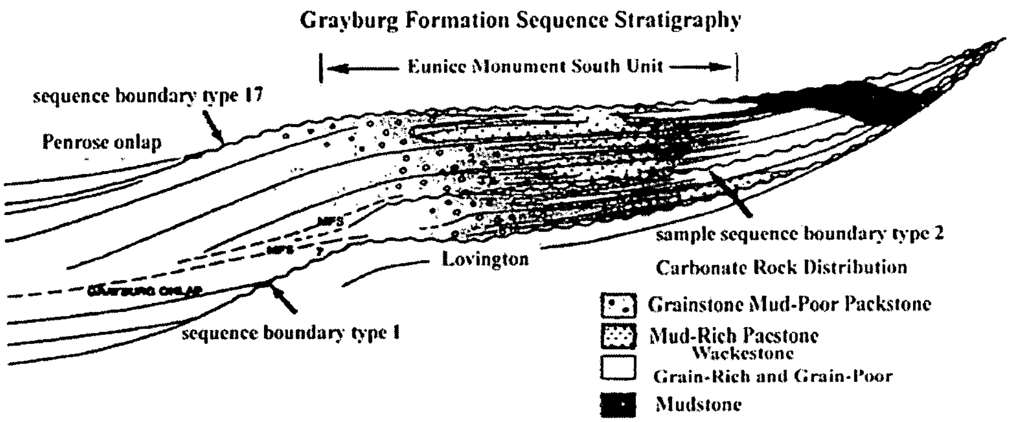
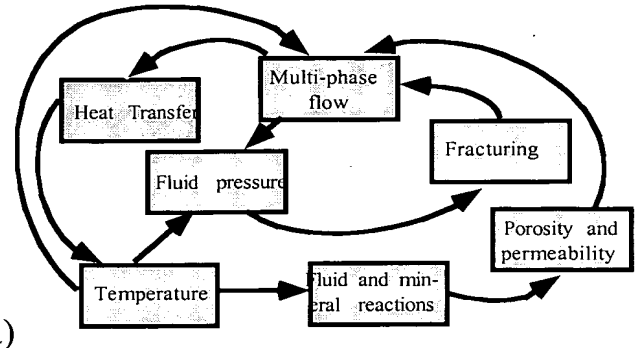
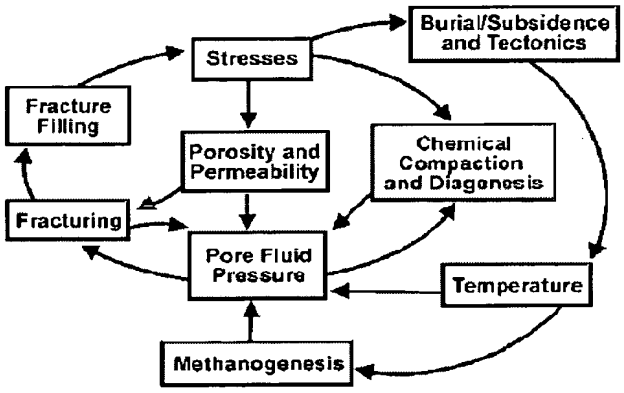

Grayburg Formation Sequence Stratigraphy
Eunice Monument South Unit
sequence boundary type 1?
Penrose onlap
sample sequence boundary type 2
Lovington
sequence boundary type 1
Carbonate Rock Distribution
Grainstone Mud-Poor Packstone
Mud-Rich Pacstone
Wackestone
Grain-Rich and Grain-Poor
Mudstone

FIG. 50b


Heat Transfer
Multi-phase flow
Fracturing
Fluid pressure
Porosity and permeability
Temperature
Fluid and mineral reactions

(a)


Stresses
Burial/Subsidence and Tectonics
Fracture Filling
Porosity and Permeability
Chemical Compaction and Diagenesis
Fracturing
Pore Fluid Pressure
Temperature
Methanogenesis

(b)

FIG. 51

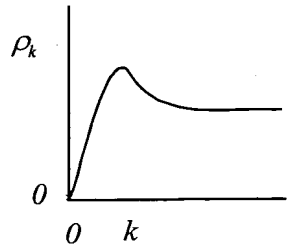


FIG. 52